HOUSEHOLD TEXTILES

FIG. 7.—FLEMISH TAPESTRY, EARLY SIXTEENTH CENTURY

(Page 16)

HOUSEHOLD TEXTILES

By

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PREFACE

Books on the subject of textiles have usually been written from the standpoint of the manufacturer or of the textile chemist. It has been the purpose of the writer to bring together in this book the general facts of most interest to the consumer. Those points have been chosen which will give a broader understanding of the textile market and aid in the selection and use of textile fabrics. Technical terms and manufacturing processes have been given only in so far as they give a general understanding of the conversion of fibers into cloth and throw light on the possibilities of adulteration.

Information has been gathered from many sources, from books, government reports, visits to factories, shops, and museums. Suggestions and references for a more extended study have been given.

The study of textiles is related to many other subjects, which can merely be suggested in a work of this size. The writer has endeavored to give that information which the lay student may understand and which may lead to a larger field of investigation.

A chapter on the Arts and Crafts movement has been included to give a broader appreciation of the field of textile art.

It is hoped that the book may serve as a text in high school courses in textiles and, with supplementary reading, as an outline for college work.

The author wishes to express her appreciation to the Boston Museum of Fine Arts for the photographs of old textiles; to the curator of Pilgrim Hall in Plymouth, Massachusetts, for photographs of implements used for spinning and weaving; to the Lowell Textile School for the picture of the Jacquard loom and the worsted card; and also to Mr. Fenwick Umpleby, of the Bradford Durfee Textile School, Fall River, for reading certain chapters in proof.

CHARLOTTE M. GIBBS.

July, 1012.

Urbana, Ill.

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CHAPTER I

EARLY DEVELOPMENT OF THE TEXTILE ARTS

THE strict definition of textile is "a fabric made by weaving" or "a material capable of being woven." For convenience, in the study of cloth, we include under the word "textile" not only the fibers capable of being woven, and woven cloth, but also other materials closely resembling woven cloth, such as felt, bark cloth, knitted and embroidered fabrics.

The modern textile industry is so enormous and its processes so complicated that one cannot understand its mechanism without long and careful study, and observation of the actual working machinery. The foundation principles, however, are the same as those of the savage woman working in the forest with the crudest implements, and the results differ only in degree of refinement. A slow but steady evolution may be traced in this, one of the earliest industries known to mankind. A much more intelligent appreciation of the modern processes may be gained through a study of the ancient industry and of the gradual development of implements and processes up to modern times.

Likewise, there is a marked evolution in the art of color and design displayed in woven fabrics, and the highly developed sense of color and design is better appreciated when the primitive love of crude color has

been studied. Man in the forests of Asia expressed himself in his arts and strove to meet his needs through his industries, just as man today expresses his love for color and his appreciation of beauty through beautiful fabrics, and manufactures cloth to protect his body and to make his home more comfortable. Among primitive races woman is the inventor, the pioneer in industries. Man has replaced her in modern manufacture, but she discovered the first principles. Modern science uses the materials which the savage woman found to be best. She learned from nature what materials and what forms to use. The debt we owe to her cannot be overestimated, for the hundreds of years of patient toil and invention by these founders of our race laid a firm foundation for modern progress.

Prehistoric Textiles. In attempting to learn something of the beginnings of weaving and spinning, we are carried back to the earliest written records, and here we find descriptions of an industry already well developed. For the earliest beginnings we must search farther into the dim past, where we have only dusty relics to instruct us; and even then we find that the birth of our industry is lost in past ages. As man first began to emerge from a state more animal than human, and felt a need for something more than the food and shelter provided by nature, he doubtless began to devise implements, clothing, and habitations of some sort; and while the skins of animals and the bark and leaves of trees first supplied his needs, slowly he developed the ability to make use of the reeds and grasses about him, and then the wool, flax, and other fibers that nature provided, and to combine these twigs

and fibers into baskets, mats, and cloth. Whether the earliest need was for shelter, for decoration, or to express modesty, we know that decoration soon followed the early textile industry, and through the ages this art and industry have developed side by side. Though information be scattered and evidences slight, they are sufficient to throw light thousands of years into the past.

FIG. 1.—EGYPTIAN LINEN
Sixth to Seventh Century A. D.

It has been the custom among primitive peoples to bury with their dead various tools, weapons, and clothing which they considered man might need in whatever journey he was to take in the life to follow. Thousands of years later the graves of these prehistoric men have been opened, and the tools which they buried have come to light, giving much information concerning the occupations of the times. Among these tools are spindles, shuttles, crude looms, combs, and other implements used in spinning and weaving. In some localities, because of peculiar conditions of climate or soil, not only have stone and wooden implements been preserved, but pottery, basketry, and even textile fabrics have been found.

In the tombs of ancient Egypt, where bodies were wrapped in cloth and then embalmed, we have examples

of textile fabrics four thousand years old. These are mostly linen, rather coarse in weave, but decorated with color in stripes and with crude representations of living creatures. The Egyptians worshiped plants, animals, and material things, and they portrayed these in their designs. Some of the fabrics are embroidered, but more commonly the designs are woven in. Figure 1 shows the character of Egyptian design when more fully developed in the early Christian era.

On the coast of Peru, where the dry saline sands are excellent preservatives, there have recently been opened graves containing relics of great interest. The Incas, a powerful race of Peruvians, had carried the textile art to a high degree of perfection in the thirteenth and fourteenth centuries, and they buried with their dead many fabrics of linen, cotton, and wool, embroidered, intricate in design, and ornamented with precious metals. A valuable collection of Peruvian textiles is in the Natural History Museum in New York, the most perfect piece being a poncho of wool, very silky in its fineness. Its surface is divided into squares, each filled with simple, geometric designs of animal and plant form. This poncho was buried in a stone box, and has come out apparently as perfect in color and texture as it went in. Nets showing different weaves and meshes, elaborate head dresses, tassels, and ornaments of various sorts, as well as patchwork in gorgeous colors, are among the collections in this museum, and also in the Boston Museum of Fine Arts.

The looms used by the Peruvians were very simple, as were those used by the Egyptians. Some of the former have been found in the graves with partly finished cloth

in them, while the latter are pictured on the walls of temple or tomb. The colors and the designs are quite similar in Egyptian and Peruvian relics, although one industry existed some hundreds of years B.C. and the other about 1300 A.D.

FIG. 2.—PERUVIAN FABRIC

Figure 2 shows a remnant of a Peruvian fabric with characteristic design and fringe.

In parts of Switzerland, during the Bronze Age, men built their homes on piles driven into the bottoms of lakes. When these houses decayed and fell into the lake, or were partly destroyed by fire, tools and fabrics

fell also, and gradually covered by a layer of peat have been preserved there for thousands of years. Sometimes several layers have been found, separated by layers of mud, illustrating different periods of history. The materials found in these lakes are very fragmentary, but serve to show that the lake dwellers knew how to spin and weave and had crude implements to work with.

Associated Arts. Aside from these and other remains of early textile art itself, we are able to learn much from the associated arts of the same periods. We find decoration on potteries, made by the imprint of the woven cloth or basketry used for holding the vessel in shape, sometimes probably molded there merely for decoration. Sometimes the decoration shows designs clearly developed for use in weaving, but not necessarily produced in this way. The Mound Builders of this country furnish us with examples of this sort. Basketry is an art practiced by many primitive peoples and is closely related to cloth weaving, since the decorations and some of the weaves are the same in both. Architecture, too, shows the influence of textile art, some of the designs used in decoration of stone showing clearly their textile origin. Evidently the two arts developed side by side for ages, the woven fabrics serving to embellish the architecture, or making a real part of the structure, when used for partitions and walls. Pictorial decoration on architecture and on pottery, stones, and tools frequently portrays the arts and industries of the times. Weaving, spinning, dyeing, and preparation of fibers are all shown in a manner crude, but distinct nevertheless. We find such decoration abundant in Egypt, Assyria, Greece, and other countries.

All of these sources furnish us with unquestionable evidences of an art and an industry existing long before written records were left. New evidences of this past life are brought to light from time to time in many parts of the globe, adding their proof that spinning and weaving were commonly practiced among our prehistoric ancestors.

Primitive Peoples of Today. Had we no history to read and no relics to study, if we look about us today we may see many examples of the early stages in development of the textile art. Tribes of people still exist whose civilization has not yet advanced to the age of manufacture by complicated processes or by machinery. The baskets, mats, and blankets woven by aboriginal peoples are recognized as being among the most beautiful produced. The workmanship of primitive peoples is marvelous when handling reeds or rushes. Their colors are natural colors and their forms are copied directly from nature. The gourd, the nest, the spider, the reptile, and other natural forms, furnish shapes and designs. An art which thus keeps close to nature, knowing no other art to copy, is sure to be beautiful. The primitive woman is thoroughly acquainted with her materials and understands their limitations. Add to this the beauty of usefulness and the result is excellent. The food and water baskets of the Pima Indian are graceful in line and shape, and the designs, though simple and often crude, are successful, while for durability the baskets are unsurpassed. (See Figure 3.)

The Indian loom, while one of the simplest in construction, produces, under the skillful touch of the Indian

man or woman, a blanket or rug so closely and thickly woven as often to be waterproof. Narrow looms are used to weave wonderful belts, saddle girts, and small

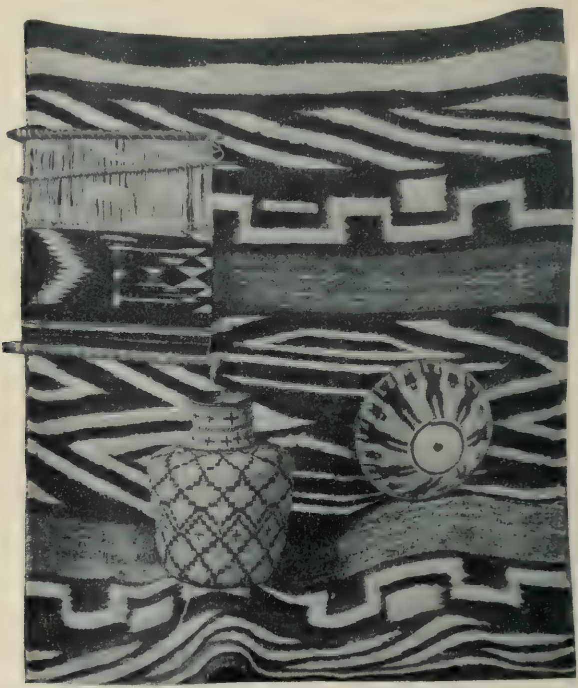

FIG. 3.—NAVAJO BLANKET. SMALL BLANKET LOOM. APACHE OLLA. PIMA FOOD BASKET

cloths, for there is no waste by cutting in the making of the aborigines' costume. The design is carried in the weaver's head, the yarns, carefully dyed beforehand, being skillfully woven to produce intricate geometric figures. There is a strength and honesty about the work which

give it a place among artistic productions. The blanket shown in Figure 3 is gray, red, and white, very thick and firm. The small loom, with partly woven blanket, is a model of the larger blanket looms. The baskets are illustrations of wonderful skill. Both blanket and baskets show the characteristic geometric designs produced in accordance with the nature of the material.

The Islands of the Pacific Ocean furnish another interesting source of primitive textiles. Figure 4 shows

FIG. 4.—BASKETS, FANS, AND GOURDS WITH CARRYING NETS
From Samoa and Hawaiian Islands

Samoan and Hawaiian baskets and fans, and food vessels from the gourd and calabash wood, with carrying nets. The simplicity of form and design is notable. Mats woven by the South Sea Islanders from the Marshall Islands (Figure 5) show some knowledge of numbers in the counting necessary to carry out the design, and very skillful manipulation of the material, which consists of Pandanus leaves slit into strands and woven by the savage without a loom. Tapa, or bark cloth from Hawaii and Samoa, is produced in a curious manner from a species

of mulberry tree. The art of making this paper-like cloth is now almost lost, but was formerly much practiced. The bark of the shoots of these trees is carefully peeled

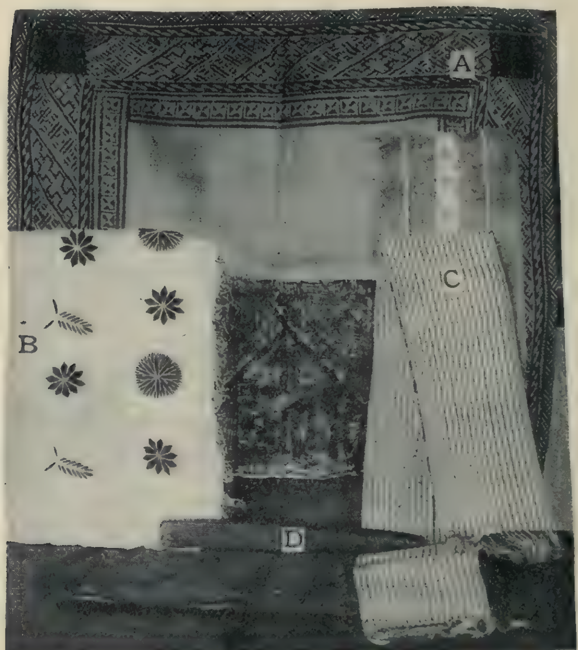

FIG. 5.—PRIMITIVE FABRICS FROM PACIFIC ISLANDS

A. Mat from Marshall Islands
B. Tapa Cloth from Hawaii
C. Tol from Gilbert Islands
D. Mallet used in beating Tapa

off, the outer bark scraped away and the under bark beaten with a grooved mallet until it is very thin and smooth. The surface of the finished cloth shows the marks of the mallet, and is either dyed a solid color or decorated with geometric designs, or with fern leaves

or other plant forms, which are dipped in dye and then laid on the surface of the fabric.

Whether we have passed through just the stage of civilization in which we find the Eskimo, the American Indian, and the South Sea Islander may be a matter of some doubt, but probably our ancestors, thousands of years ago, carried on their arts and industries in a somewhat similar manner, and the study of these primitive peoples serves to give us the stages in the development of the higher forms of industry. We must, however, bear in mind that few peoples today are entirely unaffected by modern civilization and the commercial spirit which follows in its train. An example of this is the Navajo Indian, an excellent type of primitive man, living and working in his primitive way. His blankets have been one of our best examples of a simple and beautiful art, the art of a people untutored in the modern theories of color and design, the product of the individual influenced by generations of his ancestors, but not by any foreign art. Unfortunately, the modern curiosity hunter has brought the Navajo too much before the public eye; his art has become commercialized, and the demand for his wares has caused him to produce faster than he can produce well. He has borrowed from the white man dyes which he does not know how to use, and he works now for the public rather than for himself. The consequence is that it is difficult to find the true Navajo blanket, the expression of the individual making the best product he can. So it is with other peoples in other parts of the world: and as civilization spreads, it will not be many decades before the primitive man, uninfluenced by modern

times and conditions, will be a creature of the past, and his art will be a bygone art.

Before turning to written history, let us sum up the results of our search into the dim past.

At first, among the oldest remains, crude implements for spinning and weaving have been found; then potteries with the imprint of woven material, either basketry or coarse cloth, used in molding or for decoration; next, scraps of cloth, coarse and irregular, but requiring inventiveness and manual skill for its production; and later, woven cloths of greater beauty and fineness. All of these furnish sufficient evidence to prove the existence of spinning and weaving at a very early time, and the gradual development of these arts.

Basketry and mat weaving, since the materials are coarser, probably preceded the making of textile fabrics; but we find beautiful textiles among peoples who, so far as we can ascertain, have not excelled in basketry, neither was development simultaneous in all countries. In Egypt, two thousand years ago, fabrics were made similar in many respects to those produced by the Incas in Peru in the thirteenth century A.D., while those of Peru are far superior in fineness of weave, in design, and color to the manufactures of the American Indian of today. Links in the chain of evolution are often missing, but the progress from the coarse, crude cloth found at the bottom of the Swiss lakes to the finest Egyptian mummy cloths must have been a steady one. Remnants of Egyptian and Peruvian burial cloths are interesting as a step in the development of the use of different fibers, but much more so as showing the skill to which the races had

attained in the perfection of weaving, in the use of dyes, and in the combination of colors.

Wall paintings also show that the dress of the ancient Egyptian, though simple in construction, was elaborate in color and design. Hangings of great elegance were used in the houses of the wealthy, and the court of the king was a gorgeous assemblage.

Historic Textiles. At the time when the most ancient records were written, textiles were being woven in parts of the Orient which in intricacy of design, richness of material, and splendor of color have perhaps never been surpassed. Silk, wool, cotton, and linen were all in use. Quotations from the Bible, from the Greek writers, Herodotus and Homer, and from the Roman Pliny show that, four or five centuries before the time of Christ, the countries of Arabia, Syria, Persia, and Palestine excelled in weaving beautiful materials. Still more ancient records of India and China tell of wonderful fabrics made in these countries. Purple and gold was a sign of royalty and nobility. The purple dye was laboriously obtained from a shell fish, first discovered on the shores of Tyre. The gold beaten into very thin plates was then cut into strips which were either woven flat or wound about threads of some fiber.

> "The joyful mother plies her learnèd hands
> And works all o'er the trabea golden bands;
> Draws the thin strips to all their length of gold
> To make the metal meaner threads enfold."

When woven separately or with silk, these produced the most gorgeous fabrics.

These various products of the loom furnished one of

the chief articles of commerce of the Phœnicians and also of the extensive trade of the interior of the Orient.

Homer, about 900 B.C., tells of the elaborate embroidery executed by Helen of Troy. The designs at this time were not simple and conventional, but portrayed historic events, the scenes of battle or legends. When Pericles was beautifying Athens, men and women whose names have long since perished were providing magnificent fabrics to embellish the walls and floors of the wonderful buildings. Gradually these arts spread into Western Europe, where for a long time simple spinning and weaving had been carried on. Of these early tapestries and beautiful materials we have only written descriptions or pictures, but these are vivid enough to give us a conception of what they must have been. The Roman conqueror brought to Rome silks, linens, woolens, cloth of gold and silver, decorated with precious stones, and tapestries, which, judging from the descriptions, must have excelled anything we can imagine in luxury and richness.

It is said that "the wife of the Emperor Honorius died sometime about the year 400, and when her grave was opened in 1544, the golden tissues in which her body had been shrouded were taken out and melted, amounting in weight to thirty-six pounds." [1]

In Rome, show and luxury caused many arts to decline. This was true also of the textile art, since decline of taste is shown in extravagance of dress and house furnishings as in other ways.

Gradually Italy began to produce her own fabrics.

[1] Rock. Textile Fabrics.

Spain received the art from the Moors, and in time all Europe was making priceless tapestries. This European tapestry showed the influence of Greece and Rome and also of the Orient. Art was pressed into the service of the church, and just as tapestries had previously portrayed wars, the stories of the gods, the powers of nature and mythology, they now pictured the stories of the Bible. Beautiful brocades, velvets, and silks of various kinds were made in Sicily. Naples, Florence, and Venice were all famous for their weavers. Heraldry provided designs for silks, especially at the time of the Crusades. Lucca and Genoa became famous for velvets and cloth of gold. Guilds were formed to carry on the trades, and the silk guilds and wool guilds of Italy were a prominent factor in the cities for hundreds of years.

The Renaissance in the thirteenth century gave great impetus to all art, and from then until the seventeenth century there was marvelous development in tapestry weaving. Tapestries as woven pictures are the highest expression of the weaver's art, and require the skill of both an artist and a trained workman. Tapestry weaving differs from ordinary weaving in that the warp or lengthwise threads are stretched on a frame, then the weft or cross threads are woven in by hand, not in a continuous thread from side to side, but each small part of the design is woven in separately as a different color is required. Tapestry might be called embroidery on warp threads, and because of the nature of the process any design may be produced. The art of tapestry weaving was known to the ancient Egyptians, the Greeks, the Peruvians, and other nations with a high state of civilization at an early

period. From the thirteenth to the sixteenth century, the Flemish and French produced many beautiful tapestries. Arras, a village in Northern France, became so famous that the term Arras came to be used very generally for all tapestries. In the first half of the seventeenth century, the work in France was greatly aided by the active support of the throne. Louis XIV, through his minister Colbert, reorganized the Gobelin workshop which had existed in Paris since 1607, and made it, in 1662, an establishment manufacturing for the crown alone. Since the finances of the industry had been quite precarious,

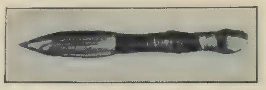

FIG. 6.—BOBBIN USED IN MAKING GOBELIN TAPESTRY

this was a great step in making the Gobelin the permanent establishment it has been since that time. A similar royal factory was established at Beauvais in 1664. These two factories during the seventeenth century produced some of the most wonderful examples of textile art known in modern history. Those who wish to go more fully into this chapter of textile history are referred to the bibliography for books dealing with this subject. It is significant to note that this art developed along with architecture, sculpture, and painting. Like them it has had its great periods and its declines, the greatest decline being in the eighteenth century. Since then the heights have not again been reached.

Reproduction in black and white gives little idea of the real beauty of tapestry, but this specimen from the

Flemish (Figure 7, frontispiece) gives some suggestion of the intricateness and the general character of some of the greatest woven masterpieces.

Before leaving the textiles of the twelfth to the eighteenth century, we must turn again to the Orient, for there was and still is carried on in Persia, Turkey, and other parts of Western Asia an industry which is, in many ways, the wonder of all times. Oriental rugs, which are so prized because of their marvelous construction, their wearing qualities, and their great beauty, are the products, not of a few great artists, but of hundreds of humble Oriental workers, in their wild mountain homes. The best of these rugs are not surpassed anywhere for beauty of color and design, while the silkiness of the wool or the fineness of the silk used produces the texture of finest velvet. Perhaps because the colors are softened by age, the oldest rugs are among the finest; but many wonderful pieces, some of them modern, have been brought into European and American markets of late years. Efforts are continually being made to imitate these rugs in modern manufacture, but the secrets of dyeing and color combination, the individuality and excellence of design learned through centuries of experience in the Orient, are not to be duplicated in a day, and the strength of hand-tied knots in each thread of the pile of an Oriental rug is not to be found in the pile of a machine-made carpet. Here again, for a more complete study, there are books full of interest and charm.

Chinese and Japanese textile art has not changed as rapidly as the European art. For centuries beautiful silks and embroideries have been produced by these coun-

tries with a character quite distinctly their own. The Oriental peoples have not become intermingled as have the Occidental. They have had a religion which is retrogressive rather than progressive, and until the invasion of Western civilization there was little change in customs, art, or dress. These peoples have exercised a wonderful manual skill in all their industries, but they have not invented. India for hundreds of years has produced muslins, the wonder of the world in fineness, but, except when foreign influence has been exerted, her methods are as crude as they were a thousand years ago.

Colonial Home Industries. The textile industry of the later eighteenth and the early nineteenth century which we shall study is very different from the weaving of tapestry or of Oriental rugs. It is the simple home industry which we find the world over. In America it is the industry of the Colonists and of our great-grandmothers. In the early days of this country and well into the nineteenth century the loom was a common possession of every home, and each housewife was her own producer. The materials made were excellent woolens and linens, not gorgeous or brilliant, to compare with the tapestries or rugs of Europe and the Orient, but representing the honest efforts of a simple, home-loving people. They are often beautiful fabrics, but beautiful because of their firm and interesting texture, the simplicity of design and color scheme, and the excellence of the materials. There was no thought of the value of time and labor which went into these materials, the main object being to produce something durable and at the same time beautiful, if possible. That the results attained the end

sought is well shown by the homespun blankets, the blue and white covers, the linen sheets that remain to this day to tell their own story. The rush of modern times has almost destroyed these home industries in the United States, but they are still to be found in a few remote parts of the country where civilization, in its advance, has not stamped them out. Now, realizing that a certain

FIG. 8.—HOMESPUNS MADE BY KENTUCKY MOUNTAIN WOMEN
From Berea College

individuality and expression of skill found in the handmade is lacking in the machine-made, many who appreciate the value of true homespun are making serious effort to preserve what is left. Figure 8 shows some of the productions of the mountain women of Kentucky, who are being encouraged in their industry by the workers of Berea College.

As this simple homespun industry contains the prin-

ciples of the modern factory system, and is its immediate predecessor, as well as the art from which all more complicated hand weaving developed, it will be worth while to dwell on it more fully in a chapter on spinning and weaving. At the present day, machine-made fabrics are, of course, most important. Today it is impossible to use hand-made materials for most purposes, but there is a plea to be made for the industry, in that it offers a field for the true expression of the individual, and there is a combination of honest wearing quality, beauty, and a certain distinction in the fabrics, not to be found in machine-made materials. The machine-made is not to be discarded, but neither should the hand-made be allowed to disappear. It is finding renewed expression today in the Arts and Crafts movement.

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  Prehistoric Textile Fabrics, p. 397.

[1] For publishers and dates see bibliography at the end of the book.

CHAPTER II

SPINNING AND WEAVING

EVOLUTION of Spinning. Spinning is the process whereby fibers are combined in such a manner that they produce a continuous thread. The origin of spinning is lost in past ages. Just when or how man first conceived the idea is unknown. Marsden, in "Cotton Spinning," says that it has been suggested that the shepherd boy tending his flocks noticed the lock of wool which had caught on a bramble, and twisting it found that the fibers would hold together, and gradually evolved a thread. By many writers, however, the origin of spinning is attributed to woman, who must, besides preparing food and utensils, provide some sort of shelter for her child, and was therefore in primitive civilization more inventive than man. Any theories concerning these beginnings are, however, merely conjecture, but it is evident that spinning is a very ancient art.

The simplest method of making a thread is to draw out from a clump of wool or other material a small amount of the fiber, twisting as it is drawn. The thread thus formed is then wound on a stone or other convenient object. It was found that if the thread was fastened to the stone and the whole twirled, the thread could be twisted faster, and one hand was left free to draw the fiber out from the mass. Among ancient relics, sticks or spindles, as they are called, sometimes of bone, are found with a slit or hook at the end, in which the thread was

caught. The spinner, holding her wool in one hand, drew out a twist of fiber and fastened it to the hook in the end of her spindle, which she then rubbed between her palm and her hip, causing it to revolve rapidly. She then dropped the spindle, and with her free hand regulated the amount of fiber which it should draw out. Soon it was discovered that a full spindle revolved better than an empty one, so a disk of clay or wood, called a whorl, was attached. This simple tool was used in all parts of the world for many centuries.

The next step in invention was the use of another simple device to hold the bunch of unspun fibers, a stick called a distaff, which could be slipped into the belt or held under the arm, thus leaving both hands free to manage the thread. Not for several hundred years was the spinning wheel invented. This combined the spindle and the distaff in one machine which had a large wheel, turned sometimes by a foot treadle, sometimes by hand; this wheel was connected by a string acting as a belt with the spindle, which in this case was placed in a horizontal position. In the end of the bench which holds the wheel and spindle, and just above the latter, was the distaff, on which the raw fiber was placed. The spinner, or "spinster," stood or sat before the wheel, and with skillful fingers drew the fiber out in a fine thread. She turned the large wheel, which in turn caused the spindle to revolve; the thread was fastened to the end of the spindle and given the desired twist. When sufficient had been drawn out, the yarn was wound upon the spindle and the operation repeated. With the large wool wheel the spinner usually walked back and forth as the yarn was

drawn out, but with the flax wheel she sat beside her work. In Colonial days every household had its wheel, and the daughters of the family were early taught to spin. After the long day of work in house and field, when the family

FIG. 9.—FLAX WHEEL

gathered around the great hearth before the blazing logs, the hum of the wheel made a pleasant accompaniment to the talk of the elders.

The spinning wheel is supposed to have been introduced into Europe about 1530, although a manuscript in the British Museum dated in the fourteenth century contains a rude picture of a woman spinning with a wheel.

In the early days in Europe and in this country, linen and woolen were the fibers most used. Cotton is much more difficult to spin by hand than are wool and linen; and although it was often combined with linen or wool, its great usefulness in the Western world dates from a later time. The Hindu, however, has used cotton for hundreds of years, and still spins the finest yarns with a spindle, although a very crude wheel is used for coarse work. He has never been excelled in the fineness of yarn spun and woven. In England, one pound of cotton fiber was spun into one hundred and sixty-seven miles of yarn, but it was impossible to weave this. The Hindu not only spins but weaves into cloth remarkably delicate yarns, so that it is said cotton shawls have been made which might be drawn through a finger ring.

To prepare wool for hand spinning, the mass of fibers was untangled by cards, which were made of wires set into wood or more often leather, and were employed like brushes, the greatest success resulting when they were slightly heated.

By the old method, the wool was often grown, sheared, washed, carded, and spun by one household. By the modern method, the long series of processes are carried on by many different machines, and the mill that spins

the yarn may be far removed from that which weaves it into cloth, and the latter, again, other than the one which bleaches and dyes it.

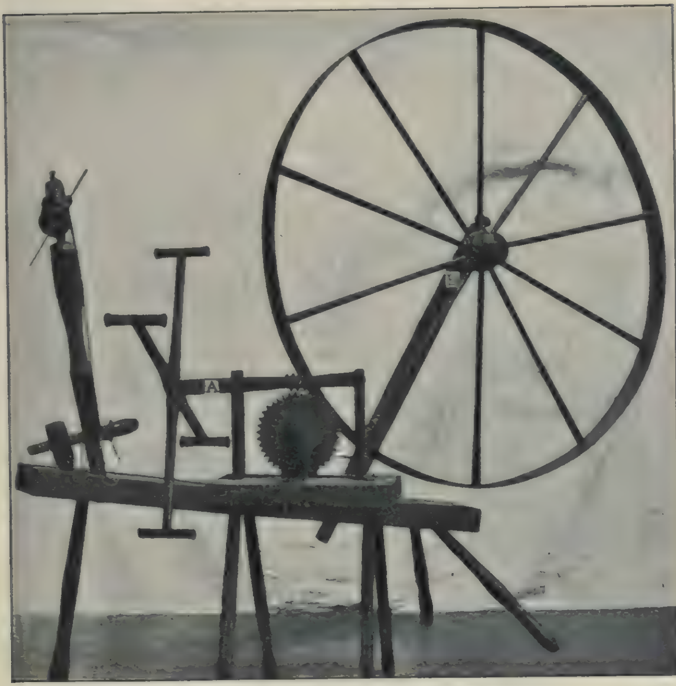

FIG. 10.—A. REEL. B. WOOL WHEEL

After the yarn was spun, it was wound into skeins on the clock reel or on pegs put around the rim of the large spinning wheel. Mrs. Alice Morse Earle, in her "Home Life in Colonial Days," gives an attractive picture of the spinning industry, with its poetry and its quaint names for the implements used. The wheels, reels, and

swifts for making and winding the yarn are interesting, and much pride was often taken in making swifts for one's wife or sweetheart. Figures 9, 10, and 11 show some of the types of winders.

FIG. 11.—YARN WINDER

Flax was more difficult to prepare, since it must first be separated from the woody fiber which surrounded it by a process of rotting or retting in water, then breaking and combing; these processes will be described more fully in Chapter VII, for the principles are the same at the present time.

A description of the preparation of cotton fibers by the Hindu, whose old methods of manufacture are still employed to a large extent, may be interesting.

The cotton gin for separating the seeds from the fiber consists of two teak wood rollers, fluted longitudinally, revolving nearly in contact, much like the modern clothes wringer. The cotton fiber is put in at one side and drawn through by the revolving rollers, which leave the seed behind. The next process, called bowing, consists in cleaning the cotton by means of a long bow, made elastic by a complication of strings. This bow is laid on top of a pile of fiber, then struck with a mallet, and the vibration jars the dirt out of the cotton

and also opens the knots. After bowing, the yarn is spun without carding.

Evolution of Weaving. Weaving is the process of interlacing two sets of parallel threads at right angles to each other, to produce cloth. The art of weaving has gone through an evolution similar to that of spinning. Again, the first stages of the development are lost in the past. The intertwining of the branches of trees may have suggested weaving in more branches to form shelters, or tree huts. The rushes from the river banks placed on the floor of cave or hut may have become entangled and suggested the weaving of mats; whatever their source, slowly and surely the suggestions developed and grew in the mind of man, until eventually woven cloth was the result. Early man wove reeds together to make mats; later, perhaps, he conceived a basket. Few and simple implements were required to supplement the skill of human hands.

Pictures on the walls of ancient Egypt show a very simple arrangement of threads stretched between two bars. Two weavers worked at one loom, which was too wide for one to reach across, and no shuttle was used. The threads woven in were only as long as the width of the loom, and thus a fringe was formed on each side. The early Greek woman stretched her lengthwise threads or warp between two bars, and stood before them interweaving the weft of her beautiful tapestry with infinite care.

The Navajo Indian loom furnishes us with the simplest type at the present time. It consists of two poles between which the warp is stretched, one pole being

fastened to the limb of a tree or to the top of two uprights set in the ground, while the other is fastened to the ground. The weaver sits on the ground in front of her loom, and, beginning at the bottom, works in her different colored yarns with the assistance of a simple shuttle. Alternate threads of the warp are fastened by a cord to a rod which, when raised, makes an opening for her filling thread. The rod is called the heald, the opening the shed. The shed for the next filling thread is opened by a stick which passes between alternate threads of the warp; a heavy stick serves as a batten to beat the filling threads together. As she progresses with her blanket, the weaver rolls it up on the lower rod and the top one is lowered. As is the case with most primitive weaving, the cloth is woven the size desired, and there is no cutting. An illustration of a small Indian loom is given on page 8.

Belts are woven by the Indians on a similar loom, which, however, usually has one end attached to the waist of the weaver; the warp also may be continuous, so that the finished part is merely pushed away from the worker.

The Hindu loom is as rude a piece of apparatus as is their spinning wheel. "It consists of two bamboo rollers, one for the warp and the other for the web, and a pair of heddles. The shuttle performs the double office of shuttle and batten, and for this purpose is made like a large netting needle, and of a length rather more than the breadth of the web. Sometimes the shuttle is short and must be thrown. This apparatus the weaver carries to a tree, under which he digs a hole (which may be called the treadle-hole) large enough to contain his legs

and the lower tackle. He then stretches his work by fastening his bamboo rollers at a proper distance from each other by means of wooden piers. The heddle-jacks[1] he fastens to some convenient branch of the tree over his head; two hooks underneath, in which he inserts his great toes, serve instead of treadles; and his long shuttle, which also performs the office of lay,[1] draws the weft through the warp and afterwards strikes it home to the fell."[2] "There is not so much as an expedient for rolling up the warp; it is stretched out to the full length of the web, which makes the house of the weaver insufficient to contain him. He is therefore obliged to work continually in the open air, and every return of inclement weather interrupts him."[3]

Step by step, devices have been added to the loom; originally the threads were beaten into place by a stick called the batten, then a rude comb was used. Finally, the reed, a device much like the comb, but consisting of a frame in which the parallel wires are set, took the place of both the simpler devices. The reed was then placed in a heavy frame, or lay, which might be swung back and forth to beat the thread into place. The heddle replaced the heald rod, and consisted of a frame of wooden rods with a hole in each, one thread going through the hole, the next through the space between the bars. Alternate threads could, by means of this implement, first be

[1] NOTE.—Heddle and lay are explained in next paragraph. Heddle-jacks are pulleys and ropes on which heddles are raised and lowered.

[2] The History of Silk, Cotton, Linen, Wool, etc. Published by C. M. Sexton.

[3] Mill. History of British India. Book II. Chapter 8.

raised above the others, making an opening, or shed, for the shuttle to pass through; then pushed below the others,

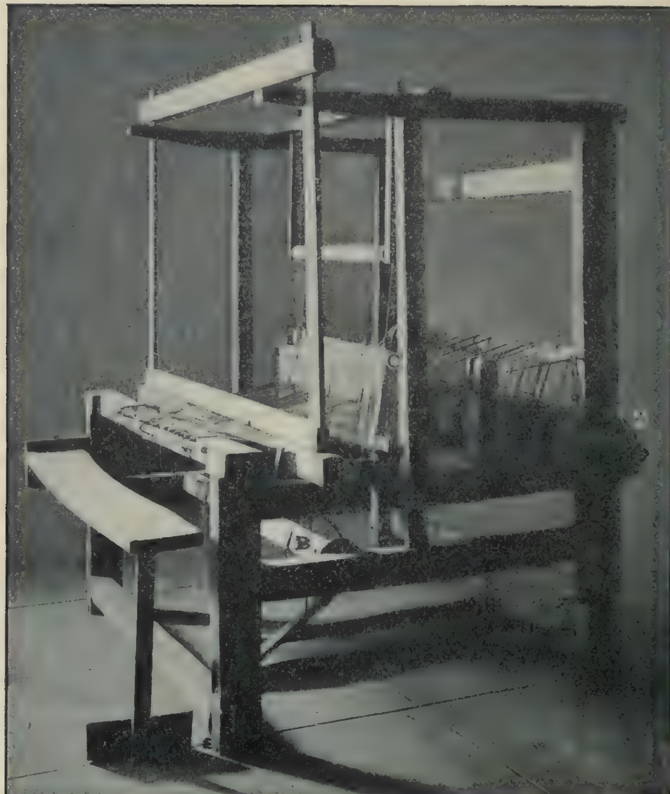

FIG. 12.—HAND LOOM OF COLONIAL DAYS

A. Warp Beam B. Cloth Beam C. Harness

making a different shed. Thus, with one device, plain weaving could be accomplished. The modern harness performs the same function, but two harnesses are used

to accomplish the work of the heald, each being raised in turn. The harness consists of a frame in which wires are strung, each wire having a loop in the center for the thread to pass through. The warp threads are put through two harnesses alternating, first one, then the other; thus, when one harness is raised half the warp is raised, with the other harness the other half of the warp. By having more than two harnesses and varying the threading of the warp, different weaves, as the twill weaves, sateen weave, etc., can be made. The hand loom used in Colonial times had become quite a complicated affair.

The Industrial Revolution. For a long period no great change came about in the machinery used for manufacturing cloth. The loom of the early eighteenth century did not differ greatly from that of the tenth century, and the spinning wheel introduced in England about the fifteenth century was still in use. A great change was felt in many ways in the middle of the eighteenth century. "It was a time of new men, new methods, and new conditions. The whole social and industrial fabric was undergoing change, and it was in connection with the cotton trade that the new life was shaping itself with the strongest force."[1] A series of remarkable inventions for manufacturing cotton cloth by machinery revolutionized the whole textile industry as their use spread to wool, flax, and silk.

The patient, laborious methods of hand work were to be replaced within a half century by wonderful machines, run first by water power, then by steam. The

[1] Burnley. Story of British Trade and Industry.

spirit of mechanical invention once thoroughly awakened has never rested, and in the field of textile industries some of its greatest works began.

It must be remembered that by the eighteenth century the textile industries were very large, employing hundreds of thousands of workers in England alone. These workers were often banded together under a master for convenience and expediency. Spinning was a long, slow process, and frequently the weaver had to remain idle because of the lack of yarns. This difficulty was increased when, in 1733, John Kay invented the fly shuttle, which greatly simplified the placing of the filling threads, throwing the shuttle across the loom by a mechanical device. With this aid the weaver could weave twice as much cloth as before. Since this device lessened the rate of wages of the weavers, for some time they declined to adopt it.

About the same time John Wyatt worked out a spinning machine which "spun the first thread of cotton ever produced without the intervention of human fingers," but he never succeeded in perfecting his invention. In 1764, James Hargreaves, a poor weaver, inspired by an overturned spinning wheel which he observed continued to revolve, made a machine which spun eight threads at a time. This "spinning jenny," named for his wife, was kept a secret for some time, until his neighbors, wondering how he could produce so much yarn, mobbed his house and destroyed the machine. Later he received £4,000 from the manufacturers of Lancashire for permission to use a machine of sixteen spindles. This machine was the cause of fierce contention between workingmen and masters. In 1769, Richard Arkwright, a barber,

working with the idea of Wyatt, perfected a spinning frame in which the thread was drawn out by a series of rollers, each pair revolving more rapidly than the one before. The yarn was twisted by the revolving of a fly attached to the spindle, and wound on bobbins. In Hargreaves' jenny the yarn was drawn out by a carriage which held the yarn to be spun and moved away from the spindles, which twisted the yarn as they revolved. The carriage then moved back and the yarn was wound on the spindles.

Samuel Crompton, another poor inventor, combined the principles of Hargreaves' and Arkwright's machines in the first spinning mule.

These inventions multiplied many fold the production of the spinners, but as yet no improvement had been made to the loom since the day of Kay's flying shuttle.

Dr. Edmund Cartwright, a country clergyman, after long experiment produced in 1785 the first loom run by other than hand power. Many improvements were made to this loom before it was wholly efficient, but the idea had been conceived. Thus within fifty years the whole industry of spinning and weaving was given new life; and although it took many years to establish machinery thoroughly, largely because of the opposition of the workingmen, who thought they would be thrown out of work and could not foresee that the industry would only be increased, yet the start had been made. Add to these inventions the perfection of a steam engine by James Watt, in 1769, which was gradually to replace water power in the running of these new machines, the invention of the saw gin for removing cotton seeds by Eli Whitney, in

1794, and we have the names of the six men who were the chief promoters, in the textile industry, of the Industrial Revolution. Although five of these six inventors were Englishmen, it was not long before the inventions were carried to other countries. Cotton, which up to this time had held a very small place in the textile world because of the difficulty of removing seeds and spinning by hand, now jumped rapidly to the top, and with its rise flax declined. The mob riots and destruction of machinery gradually died out, although with the commercial depression caused by wars in 1811–1812 a riotous band of workmen called Luddites, in England, began again the fight against the machine, but this lasted only for a short time. In the United States the difficulty of introducing machinery arose from a different cause. The English, during the period before the War of Independence, were doing everything possible to destroy the home industries of these colonies, consequently they forbade the introduction of spinning machinery into the country. It was not until after the Revolution that a spinning machine was finally introduced by Samuel Slater, who had become so thoroughly familiar with Arkwright's machines in England that he was able to construct one from memory in Pawtucket, Rhode Island, in 1790. Laws still forbade the bringing of either models or drawings from England. The power loom was not used in this country until after the War of 1812.

Thus have the arts of spinning and weaving developed from a fireside industry to one of the greatest manufacturing industries of our time. Household arts, requiring considerable manual skill, they have developed

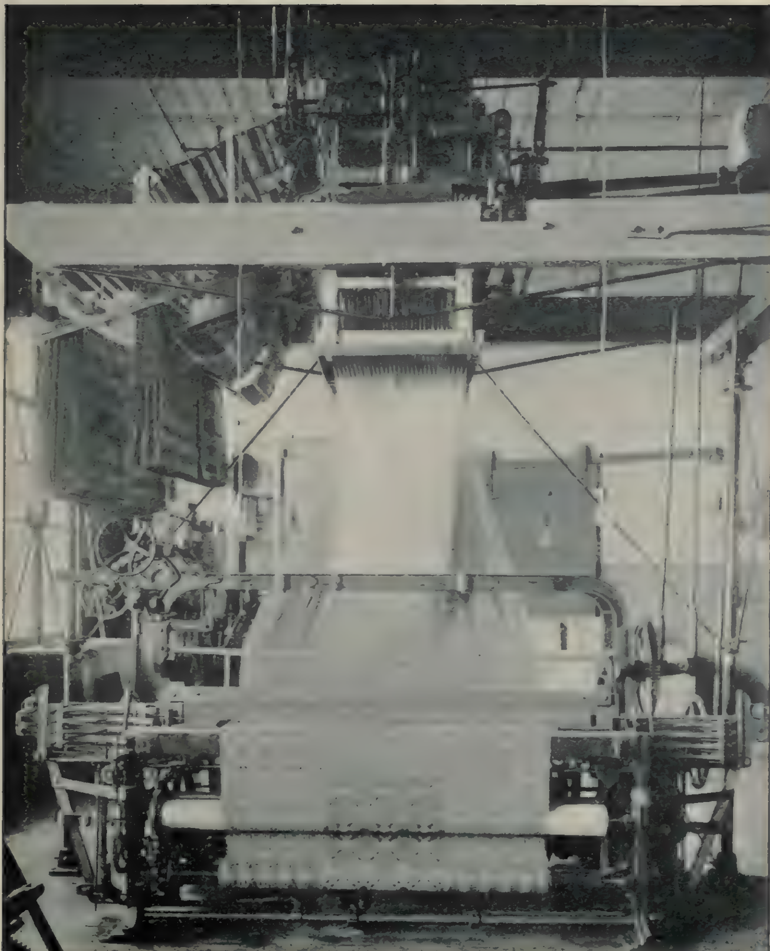

Fig. 13.—Jacquard Loom

into mechanical processes, in which the skilled intellect has supplied the machines and the unskilled worker superintends their running. No longer does the blanket on our beds express long hours of patient labor, the hum of the spinning wheel accompanied by a song, or the thwack of the loom in the corner of the living room. Now we sleep under blankets which represent, it is true, hours of labor, not the labor of a loving mother or sister, but of many machines, watched by human beings almost machines themselves, working in rooms where the hum of the spinning is no longer musical, but its noise is so great as to be deafening, and the thwack of a hundred looms deadens all the finer sense of hearing. The progress of Western civilization has demanded these things. The hurry and rush of modern life have little place for the quiet household industry, our homes are no longer the factories of the times; and in many ways it is well.

The poetic side of home industries was only a small part, unfortunately. In this country conditions had not grown as bad as they were in England, where "the domestic laborer's home, instead of being the poetic one, was very far from the character poetry has given it. Huddled together in his hut, not a cottage, the weaver's family lived and worked, without conveniences, good air, good food, and without much intelligence. Drunkenness and theft made each home the scene of crime and want and disorder. Superstition ruled and envy swayed the workers. If the members of a family endowed with more virtue and intelligence than the common herd tried to so conduct themselves as to secure at least self-respect, they were either abused or ostracized by their neighbors. The

ignorance under the old system added to the squalor of the homes under it, and what all these elements failed to produce in making the hut an actual den was faithfully performed, in too many instances, by the swine of the family. The reports of the Poor Laws Commissioners of England are truer exponents of conditions than poetry, and show more faithfully the demoralizing agency of pauperism and of all the other evils which were so prolific under the hand system of work."[1]

When our linens wear out in a few washings and our silks split after a few wearings, we sometimes wish for the good old homespuns, which wore for a hundred years. We wish for the honest, all wool materials, which were not weakened in the washing or rotted in the dye pot, and which showed in every thread the mark of the individual who made them. As far as evenness of thread and weave and beautiful finish can make it, modern cloth is perfect in every respect, but that very perfection sometimes grows monotonous and we long for the irregular threads of the homespun. Since there are still many parts of this country where the art of hand weaving is not lost, let us preserve it, not that its products may compete in the commercial world with the factory woven, but that we may still have an art which expresses a simple, honest, and quiet life.

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[1] Wright. Industrial Evolution of the United States, p. 346.

CHAPTER III

CLASSIFICATION OF FIBERS

NATURE has been lavish in the supply of materials that she has placed in the hands of man, from which he may fashion shelter, clothing, implements, and ornaments. We have seen how savage woman learned the use of the reeds and twigs about her, and so perfected their use that civilized man cannot surpass her skill. Primitive woman developed the art of spinning and weaving finer and finer materials, and that development has gone on laboriously through the centuries.

Modern manufacturing industry uses only a small number of fibers, those which have proved most suitable for spinning and weaving, but the energy and skill of designer and chemist have so altered the appearance and quality of these few fibers when woven into cloth that it sometimes requires considerable knowledge to recognize them. As competition in industry becomes closer, and the demand for novelty increases, methods of combining different fibers and of covering defects with the finish of the cloth are constantly improved; and if one is to choose intelligently from the offerings of the market, it is necessary to know something of the character of the fibers and the methods used by the manufacturer.

Requirements of a Fiber. "In order to be serviceable in a textile fabric, a fiber must possess sufficient length to be woven and a physical structure which

will permit of several fibers being spun together, thereby yielding a continuous thread of considerable tensile strength and pliability."[1] These characteristics are present in greatest degree in cotton, linen, wool, and silk, and all these may be successfully bleached and dyed. The following simple classification gives the fibers which may be used, according to their origin, and aids in the study of characteristics.

Vegetable Fibers. Cotton, linen, jute, hemp, ramie, pineapple, aloe, and many other plant fibers used more or less in different parts of the globe.

Animal Fibers. Silk, the wool of sheep, alpaca, llama, camel, angora goat, and other hairs or wools of animals used for weaving or felting into cloth.

Mineral and Artificial Fibers. This group is not very important to the average student of textiles. Asbestos is the common example, and is chiefly valuable for its non-conducting and fireproof qualities. Although the use of asbestos for spinning and weaving is limited it may be mixed with cotton or linen and spun, the vegetable fiber being removed later by burning, or it may be spun alone.

Among the artificial fibers used might be mentioned various metallic threads, but the most important fiber is artificial silk. It is a derivative either of cellulose or of gelatin, and is sometimes used, as the name implies, as a substitute for silk.

General Characteristics. Vegetable fibers are plant cells. Their structure is simple and they are largely made up of cellulose, with more or less foreign material,

[1] Matthews. Textile Fibres, p. 1.

such as plant waxes, resins, etc. They are various parts of the plants, such as seed hairs, as cotton; stem fibers, as flax, hemp, jute, and ramie; leaf fibers, as Manila hemp and various species of aloe; or finally, they may be fruit fibers, as coir, or cocoanut fiber, which comes from the covering of the cocoanut fruit.

The seed hairs are single-celled fibers, almost pure cellulose; the bast fibers, or those coming from the stem of the plants, are multicellular, and must be separated from the woody material in which they are imbedded.

Animal fibers are nitrogenous substances, protein, containing carbon, hydrogen, oxygen, nitrogen, and, in some cases, sulphur, phosphorus, and other mineral matters. They are either appendages to the skin of animals, as wool and the various hair fibers, or they are animal secretions, as silk and the secretion of various spiders, mollusks, etc.

The difference in structure of the individual fibers and classes of fibers, and the difference in chemical reactions, makes necessary very different methods in the treatment of these fibers in their manufacture into cloth.

In physical structure the fibers differ in length, diameter, strength, elasticity, color, luster, and microscopic characteristics.

Cotton is the shortest fiber, varying in length from one-half inch to two and one-half inches. Wool varies in length from one inch to seven or eight inches. Silk is a long fiber, being continuous for perhaps four hundred yards in the best cocoons, while linen usually is twelve to thirty-six inches in length. The diameter of the different fibers varies so that it is difficult to compare them;

the finest, however, are found in silk and the coarsest in wool and flax. Silk is the strongest fiber, cotton and linen coming next in order. Silk and wool are most elastic, linen being least so. In color, cotton may be pure white or nearly yellow; wool varies from white to gray, brown and black being less common; linen, according to methods of treatment in separating the fiber from the stalks, is found in different shades of tan, brown, and

FIG. 14.—WOOL AND COTTON FIBERS

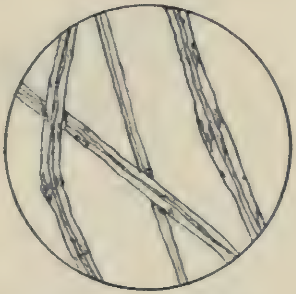

FIG. 15.—LINEN FIBERS

gray. Silk varies from almost pure white to quite a deep yellow or tan. Again, silk has more luster than other fibers, and linen has more than cotton or wool. The luster of the different fibers may be increased by physical or chemical treatment. These different qualities readily show why silk is such a valuable fiber. Wool, because of its hygroscopic and non-conductive qualities, is excellent for clothing; cotton is cheap and to a certain extent may replace the others; while linen is valued chiefly for wearing quality and texture.

Microscopic Characteristics. With the aid of the

microscope it is quite easy to distinguish one fiber from another: cotton by the spiral twist which the flat, ribbon-like fiber always has, wool by its scale-like surface, linen by apparent joints and crosswise markings, and silk by its structureless, transparent, lustrous surface.

Since a thorough understanding of the cloth made from these fibers requires a careful study of their characteristics, the method of manufacturing them into cloth, the adulterations, etc., a detailed account will be given of wool, cotton, linen, and silk. Brief mention may here be made of some of the minor fibers which are, however, found to quite a large extent on our markets.

Minor Fibers

Ramie. One of the most promising vegetable fibers used for centuries in India and China is just coming into use in this country. Ramie or China grass, from the stem of a stingless nettle, is a lustrous, strong fiber, and should hold a high place among vegetable fibers. The development of the ramie industry has been retarded in this country because of the difficulty of separating the fiber from the woody portion of the stem. It is not possible to destroy the gum which binds the fibers together by as simple a process as the retting of flax, that is, by allowing it to decay in water.

In India and China, where large quantities of the fiber are manufactured into grass linens, the decortication is carried out by hand. A mechanical process has been perfected in this country for effecting this separation, and ramie is now more commonly used. Up to the present time, however, its use is largely for adulteration

of linen or silk, a fact to be deplored, since it has such valuable characteristics of its own.

In strength, ramie stands among the first of vegetable fibers; in luster and fineness it approaches silk, and it is very slightly affected by moisture.

Two to three crops of ramie may be produced in one year, and the yield of fiber per acre is very large.

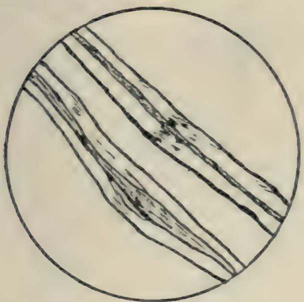

FIG. 16.—RAMIE FIBERS

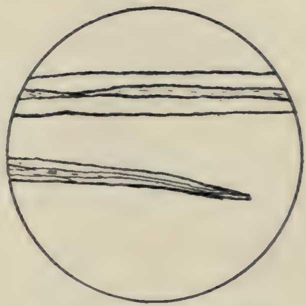

FIG. 17.—JUTE FIBERS

Attempts are being made by the Department of Agriculture to increase the production in this country, but up to the present time it has been grown only in an experimental way. Climate and soil seem to be favorable; the difficulty apparently is to arouse interest in the culture and manufacture of the fiber.

Jute is the bast fiber of a plant growing largely in India and the East Indies. The stalk, which contains the fiber, grows from five to ten feet in height. It is freed from leaves, steeped in water to rot the stems, and the woody tissue is removed. The fiber thus obtained is long, yellowish in color, and has considerable luster. There are several uses to which jute is put, but it is mostly used

for coarse bagging or for the back of carpets and rugs. Although jute is strong, takes dyes readily, and may be divided into very fine fibers, its use is limited because of the fact that when wet it rapidly deteriorates. Because of its cheapness it is frequently used to adulterate other fibers, or is woven with cotton or linen to produce effective, inexpensive upholstery materials.

Hemp is another bast fiber, obtained in much the same way as flax or jute. There are many varieties, most of which are used for twine, although fine Manila hemp is used in the Philippines for clothing material. Large amounts of Manila hemp, a leaf stalk fiber, are imported into this country for the manufacture of rope. This fiber is much more valuable than jute, as it withstands the action of water and is very strong. Other varieties of hemp, although not as strong as Manila, are also used for cordage.

Vegetable Silk. This name includes a number of fibers, the downy coverings of seeds of plants or trees. These fibers are not capable of being spun, but are used for stuffing mattresses or cushions. Kapok, or silk-cotton tree, and milkweed are the most common; in France, the latter has been spun with a large percentage of wool to produce a very attractive cloth.

Pina, or pineapple cloth, is made from the fiber obtained from the leaf of the pineapple plant. Woven with silk it makes a beautiful fabric. In the Philippines, where this material is used in large quantities for clothing, the natives separate it from the leaves by a laborious process of scraping.

Coir, or cocoanut fiber, comes from the shell of the

cocoanut. It is a stiff, harsh fiber, reddish brown in color, and is used for rope and mats. The fiber is separated from the rest of the shell by soaking in sea-water for several months, when the fruit is rotted and may be easily separated. The separation is sometimes effected by steaming.

Many other vegetable fibers are used in different parts of the world, but are not of great importance to us. We are most interested in those which are used in the markets of this country.

General Process of Manufacture

In manufacturing fibers into yarn and cloth there are many processes to be gone through and many machines to carry them out. Each year sees improvements and also new devices of the manufacturer to cheapen the process, and new methods of adding to the product by adulterations of one sort or another. It will be well to study in some detail the manufacture of cloth and some of the stages through which the fibers must pass. These steps may, perhaps, be easier to understand if a general explanation is given first.

All fibers as they are produced by nature are combined with more or less foreign matter which must be removed before the raw fiber is obtained. Cotton must be separated from pod and seeds, wool from dirt and grease, flax from the woody stalks, and silk from part of the gum and the tangled fibers of the cocoon. With the exception of silk, all fibers, when they have been freed from this foreign material, are somewhat entangled and must be straightened out, brushed or combed, until they

lie more or less parallel. In some cases the long fibers must be separated from the short, making two or more grades. A rope must be formed, which may be pulled out finer and finer, then given the twist necessary to hold the fibers together, and yarn is the result.

Frequently, before weaving, the yarn must be made more compact or held together by the addition of a starchy mixture, so that it will stand the strain of the loom. Warping and drawing the thread in place in the loom are processes preparatory to weaving, while "finishing" prepares the woven cloth for the fastidious public.

Bleaching, dyeing, or printing gives the desired color to raw fiber, yarn, or cloth, as the case demands.

This, very briefly, is the course through the mill which every fiber must travel. The variations from it are many, and the actual processes are so complicated that only the initiated may understand them thoroughly; but the underlying principles are the same as they were when the Colonial dames spun and wove by the side of the open fire.

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CHAPTER IV

COTTON

HISTORY. As has been stated, cotton is a vegetable fiber coming from the seed pod of the cotton plant. This plant is indigenous to many countries, and was used in different parts of the world at the dawn of history. Its use in India seems to extend farther back into the centuries than in any other country, judging from the fact that in writings of 800 B.C. a highly developed cotton industry is mentioned. For hundreds of years India was the center of this industry.

In Egypt we find mention of cotton grown about 325 B.C. From the writings of Nearchus, who descended the Indus and navigated the coast of Persia, we learn that cotton was raised in Persia, but it is likely this was originally brought from India. One of the early articles of trade in the Red and Mediterranean Seas was cotton cloth. The introduction into Europe was, however, very slow. Its manufacture was carried into Spain by the Moors and gradually spread into Northern Europe. Even in the fifteenth century it was not at all common in Europe, as shown by the fact that cotton was supposed by some to be the fleece of a sheep which grew on a plant, and when hungry stooped over and ate grass from the ground.

In America the cotton industry is much older than in Europe. Columbus discovered cotton in the West Indies.

Cortez found the Mexicans weaving clothes, also carpets, tapestries, and many other articles, from cotton dyed with vegetable dyes. Magellan found it in Brazil, showing it to be indigenous to the American continent as well as to India. The Peruvians, as we have seen, had a highly developed textile industry when conquered by Pizarro in 1527–1532, and cotton was one of their most used textiles.

The manufacture of cotton into cloth by hand processes is much more difficult than the manufacture of wool and linen. Great manual skill is required, as well as the proper atmosphere. These essentials the Hindu has possessed for ages, and generation after generation of cotton spinning and weaving have produced a perfection which no other nation has been able to reach. In fact, until the invention of modern textile machinery, Europe could in no way compete with India. During the seventeenth and eighteenth centuries, before the introduction of power machines for spinning and weaving, when the trade between England and India had become flourishing, India cottons became very popular in England; so alarmed were the people lest these cottons should ruin the English woolen and linen industries that laws were passed limiting the use of cotton among the middle classes.

Distribution. We have seen that cotton is indigenous to many lands. It may be raised successfully between the latitudes 45° North and 35° South. The great cotton-producing countries between these limits are the Southern United States, Egypt, India, Brazil, and Peru. In other countries cotton is raised to some extent, but not enough for exportation. The United States leads in production with about three-fourths of the world's

crop; Egypt is second in amount exported, although India raises more. Texas is the largest producing state in America, while the other states along the Gulf coast, as well as Georgia, Tennessee, and the Carolinas, contribute their share.

The conditions which determine where cotton shall be raised most successfully are climate and soil. The season must be a long one, with rainfall during the first part and sunshine during the latter part. For the best crop, the soil should be a light loam. A heavy soil produces too much foliage and not enough fiber, a sandy soil does not hold enough water, but a light loam holds heat and water and produces the best results. The nearness to sea and sea level also affect the quality of cotton, the altitude and the presence of salt in the soil apparently influencing the growth of the plant.

Varieties. Cotton belongs to the genus **Gossypium** of the order **Malvaccae.** Many species are named by botanists; the four principal ones, however, are:

Gossypium hirsutum—most American cottons.

Gossypium Barbadense—Sea Island and Brown Egyptian.

Gossypium Peruvianum—South American.

Gossypium Herbaceum—short staple—Asian.

These species are shrubs, growing to a height of from three to six feet, having many branches, and bearing alternate three-pointed leaves. The flower has five petals, varying in color from white to yellowish pink. The fruit, or so-called boll, has from three to five segments, and when ripe bursts open, disclosing a mass of soft, white, downy fibers, which are attached to the seeds. These

fibers, before ripening, are tubular cells pointed at one end and attached to the seed at the other. As the seed ripens, the pressure inside the pod causes the cell wall to flatten, the walls become thicker, and with the flattening comes a spiral twist to the cell, due probably to the withdrawal of the protoplasm and the manner in which the material is deposited on the inside of the cell wall.

There are several classifications of cotton used by buyers or growers. Perhaps the names most commonly used are those suggesting the locality in which the cotton is raised. Sea Island is long, fine, silky cotton, originally raised only on the islands along the coast of South Carolina and Georgia and on certain other sea islands, but now raised largely in the states along the coast. This cotton is the most valuable on the market, though certain Egyptian cotton is a very close second. That which is cultivated on the Sea Islands is finer than that grown away from the coast. The largest crop in the United States is the Upland cotton grown throughout the South. Orleans cotton is very valuable. Egyptian cotton is long, has a good luster, and is fine. East Indian cotton is coarser and shorter, has not such a good luster, but, as a rule, is very strong. The causes for different varieties of cotton seem to be climate, soil, fertilization, and careful selection of seed, as well as cultivation and some minor influences.

Cultivation. The time for planting cotton naturally varies in different climates. In the United States, in February, the fields are cleared of the last year's stalks, and the ground is plowed and prepared for rows about four feet apart. The seeds are planted between March 1

and June 10, although rarely as late as June, and the plant comes up in about fifteen days. Thirty-five to forty-five days later the first buds appear, and after sixty-five days more the crop is ready to pick. Thus, four months is about the shortest duration of time between the planting and the ripening of the seeds.

Cultivation of the crop is required when the plants are young, and as considerable loss is suffered from various pests and diseases, a great deal of attention has been given in the last few years to methods of fighting these destroyers. The cotton worm and other insects, fungi, and diseases cause much loss every year, but the cotton-boll weevil is probably the most serious pest.

Importance of Industry. The importance of the cotton crop to this country has been very great, and its importance to our Southern states can hardly be estimated. Cotton is the largest textile industry, and as a world industry ranks very high. The importance to other countries of the cotton crop of the United States is shown by the fact that during our Civil War it was only by the greatest effort that a terrible famine was prevented among the cotton-mill hands in parts of England. At the present time, England and other European countries are encouraging in every possible way cotton production in their own colonies which lie within the cotton belt, in order that they may not be so dependent on the crop of the United States.

Physical and Chemical Structure and Characteristics. We have said that the physical structure of a fiber determines whether or not it may be used in textile manufacture. The peculiar structure of cotton which

makes it suitable for spinning is the twist which the fiber takes on ripening. Cotton fibers are short in comparison with others used for manufacture, being three-fourths of an inch to two inches in length, the greater number varying from one to one and one-half inches. Were it not for the characteristic spiral twist which helps hold the fibers together, it would be extremely difficult to spin. Under the microscope the cotton fiber appears like a twisted ribbon, with the edges thicker than the central part. Cross sections show an irregular form, somewhat oval, with thick walls and an opening in the center. Different fibers vary as to the number of twists. There are sometimes present unripe fibers, showing no internal structure and no spiral twist, while different varieties of ripe fibers also vary in amount of twist. The size of the cotton fiber also varies greatly. Sea Island is the finest fiber, while the coarsest cottons sometimes reach a diameter six or seven times greater. In tensile strength cotton stands between silk and wool, and in elasticity it is below either, although more elastic than linen.

The most common color of the cotton fiber is a creamy white, but it is sometimes golden or quite yellow, as Nankin cotton. The luster of the fibers varies in different kinds of cotton, and is most marked in the long, silky Sea Island.

The hygroscopic quality of a fiber is its ability to absorb water. Cloth may absorb moisture in two ways. It may merely take the moisture up in the spaces between the threads of the cloth, giving it a damp feeling, or the fiber may absorb the moisture into itself. It is this second

quality which we call the hygroscopic quality. Ordinarily, cotton holds from five to eight per cent of this hygroscopic moisture, although it may, in a moist atmosphere, hold much more. The spinning of cotton is greatly affected by the amount of moisture present, therefore artificial humidity is usually maintained in the spinning room. Cotton which has been freed from the vegetable wax adhering to it is much more hygroscopic, and is known as absorbent cotton. Cotton withstands heat

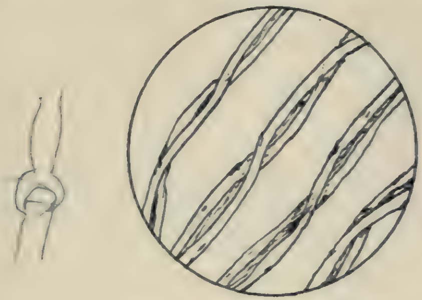

FIG. 18.—COTTON FIBERS

better than animal fibers. At 250° C. it begins to turn brown. It burns freely in the air, with a luminous flame.

Certain chemical actions distinguish vegetable from animal fibers. Cotton is largely cellulose. The surface of the fiber is protected by a layer of vegetable wax and oil, and there is a small amount of coloring matter. The natural impurities are very small, being from four to five per cent, and consisting of small particles of seed, leaves, and dust. In its chemical behavior the reactions of cotton are those of cellulose. Mineral acids destroy the fiber;

very concentrated sulphuric acid dissolves it, while weaker acids disintegrate it, so that the fiber may be reduced to dust when dried. Dilute acids do not affect the cotton while wet. Concentrated caustic alkalies bring about a change in cellulose known as mercerization. This will be referred to again. Dilute solutions of alkalies have no injurious effect on cotton unless exposed to the air, when they weaken it.

These reactions are important in the bleaching and dyeing of cotton as well as in some household processes. A stain may be removed from cotton cloth with a dilute acid and the cloth be unharmed. If, however, that acid is left on the cloth until it dries thoroughly and becomes more concentrated, it may destroy the fiber. If a hot iron is put on the cloth before the acid is thoroughly removed, a hole will doubtless be the result. Cleaning powders containing free alkali must be thoroughly removed or they weaken the fiber. Cotton does not take dyestuffs readily. In most cases an assistant is required.

Preparation for Market. When the seed pod has burst open, disclosing its treasure of snowy fibers, the time for hard and rapid work has begun. The problem of picking is sometimes a serious one. The crop must be gathered before rain or frost has had a chance to injure or destroy it, and there must be many laborers for the picking. Recently a machine which promises better than those previously tried has been invented for picking cotton and may revolutionize this part of the industry. When the crop has been gathered, before being shipped the seeds must be removed. This process of separating the fiber from the seeds is known as ginning. Until 1794

this was done by hand; then Eli Whitney invented the cotton gin, a machine which separates the fibers from the seeds by saws projecting through wire grating into a hopper. The cotton is put into the hopper, the fibers are caught by the revolving saw; but the seeds, being too large to go through the grating, are left behind. This gin is used for American cottons, except the long Sea Island fiber. This is ginned by the roller process, which consists merely in passing the fibers between rollers which do not allow the seeds to pass. The latter method has been employed in a rude way in India for many years.

By the hand process, five pounds of cotton could be picked from the seed by one person in a week. By the saw gin, five hundred pounds may be seeded in an hour, but this is too rapid for the best interests of the fiber. The cotton seeds are a valuable part of the cotton crop, although for a long time they were a waste product. Cotton-seed oil, used for cooking purposes, is obtained by pressing the seeds; cotton-seed meal, after the oil has been removed, furnishes cattle and poultry food; and the hulls are used as a fertilizer.

When the seeds have been removed, the cotton fiber is put into bales, varying in weight, but usually, in this country, of about five hundred pounds. These bales are compressed by a hydraulic press until they are very compact, are wrapped in burlap, bound with iron hoops, and then sent to market. A great deal of criticism has been made of the American cotton bale, because it often bursts open in transportation and because of the bulkiness. The cotton becomes dirty and absorbs a large amount of moisture if the conditions are right, and it is difficult

to transport. An effort is now being made to improve the bales.

Manufacture. The manufacture of cotton differs in its details in different countries. In England, spinning, weaving, finishing, dyeing, weaving of fine goods, of coarse goods, prints, or ginghams are carried on by different firms. In this country there is much more centralization, one mill often carrying through all the processes from the raw fiber to the finished cloth and producing a variety of kinds of cloth. The processes necessary to perform the carding, spinning, and weaving of cotton into cloth by machinery are varied, and the machines for carrying them out are complicated. In order that they may be more easily understood, they may be grouped under six heads:

Opening and cleaning.
Preparation for carding and spinning.
Carding and spinning.
Preparation for weaving.
Weaving.
Finishing.

Opening and Cleaning. When the cotton reaches the factory it is much tangled, having been compressed for some time in the bales. It also contains a considerable amount of impurity—pieces of seeds, leaves, and sticks, as well as dust and dirt, collected on the way to the factory. The first thing necessary is to open the bales and pull this cotton apart. The tangled mass is thrown into a large hopper, where an apron covered with hooks pulls it apart. It is sent by compressed air to another machine, where the process is continued and a blast of air blows

out the loose particles of leaves, dust, etc. From this, the scutching machine, the cotton comes out in a thick carpet-like lap, which must be of uniform thickness.

Preparation for Carding and Spinning. The fiber for medium and medium fine yarns is carded. When cotton yarn was manufactured by hand, this carding consisted of brushing the cotton on brushes made of wire bristles mounted on leather, until the fibers were smooth and parallel. The same result is now accomplished by machinery, large cylinders covered with short bristles revolving in contact with small cylinders likewise covered with bristles. The fiber comes out from this treatment in a very thin sheet, somewhat irregular, but with the fibers in a more or less parallel position. This lap is condensed into a soft rope or sliver by passing through a funnel. To make the slivers even and the fibers more parallel, several processes of drawing follow. The slivers are doubled several times and then drawn out; each time the process is repeated the sliver is drawn out finer, until at last the ropes are even and small enough for the final process of spinning. The strands from different stages in drawing are known as sliver, slubbing, intermediate, and roving.

Spinning. The final spinning into yarn consists of drawing out the roving strand finer and giving it a twist. Two-ply yarn is made by twisting together two yarns, three-ply, three yarns, etc. The air in spinning rooms should be moist and heated to 70° to 90° F. Cotton may be spun on a frame or on a mule, which differ as follows:

In the ring and fly frames, series of rollers, each set

revolving faster than the one before, draw out the cotton strand. The twist is then given by a "flier," or a ring which revolves around the bobbin and also feeds the thread to the bobbin. The mule is much more complicated. The spools of roving to be spun and the drawing rollers are on an immovable part of the machine, while the spindles are on a carriage. The carriage moves away from the main machine as the thread is drawn out and twisted, then moves back as the thread is wound on the bobbins.

The mule produces a yarn of greater elasticity, more uniform twist, and is used for best grades of fine yarn, although the frames are partially replacing the mule because they are cheaper to operate. The mule requires more space and more skilled labor to operate it. The yarn from the spinning machines is wound on cops and is ready to be sent to the dyer or to the weaver. Some kinds of goods, as ginghams, have the yarn bleached and dyed before weaving, others not until after weaving. Fancy yarns are made by combinations of different colored yarns, by irregular twisting, and by various other methods.

Preparation for Weaving. In order that warp yarns may hold together well, be more compact, and not rub fuzzy in weaving, they are sized. This sizing is the immersion of the yarns in a solution of gums, starches, etc. Light sizing, ten to twenty-five per cent of the weight of the yarn, is put on warps which are to be bleached and dyed afterwards. Medium sizing, twenty-five to fifty per cent, is put on to the warp of light cloth which is to be sent out in an unfinished state. Heavy sizing, fifty to one hundred per cent, is used on the warp

of coarse fabrics, as linings and paddings; while extra heavy, one hundred per cent or more, is rarely used. The materials used in sizing may be classed under four heads.

Adhesive bodies are flour, starch, farina, sago, and dextrine. These also are weighting bodies.

Softening bodies are palm oil, castor oil, cocoa oil, olive oil, soaps, etc.

Weighting bodies are china clay, magnesium or zinc chloride, and the adhesive bodies given above.

Antiseptics, zinc chloride, both prevents mildew and is a weighting body.

Not all of these materials are used in one sizing mixture, but all four classes may be found in a size which is to be left on the cloth. If the softening body is omitted in a heavy size, the yarn is too harsh for weaving; if the magnesium chloride is omitted, the fiber is too dry, as this is a deliquescent salt and is necessary. If the zinc chloride is left out, the fabric may mildew or decay entirely.

Warping is the series of processes by which the warp is put into the warp beam which goes into the loom. It consists in rewinding threads from the cops. If the material is to be striped, the threads must be put onto the warp beam in stripes in the order they are to appear in the cloth. Drawing in is the process of threading the warp through the harnesses and the reed of the loom. Up to the present time, drawing in is done almost entirely by hand, although a machine has been invented which ties a new warp onto an old one before the old one is drawn out of the loom, thus pulling the new in as the old is drawn out. There is also now a machine to draw

the threads through the harnesses, by which the work may be done in one-third the time required by hand.

Weaving. The designing and setting up a warp for a figured design is the largest part of the work, for, once the loom is ready, the shuttles fly back and forth, changing from one color to another automatically. The reed beats up the cloth, and if a warp thread breaks a ring drops and stops the machinery. The weaver in a modern factory tends from six to ten looms, and only needs watch them to see that they are running properly and to tie a thread when it breaks.

There are dozens of effects produced by weave, but all combinations may be traced to three simple foundation weaves. In the plain weave, there is a regular interlacing of warp and weft as in darning. In the twill weave, the weft may go under two warp threads, then over two, and so on, the next weft taking up different threads, so that the effect produced will be a diagonal stripe. In the sateen weave, the threads are so arranged that only one series, either warp or weft, appears on the surface, the other series being entirely concealed.

The rib weave is a modification of the plain weave, in which a heavy stripe is produced by combining two or more warp threads. The basket weave is produced by weaving both warp and filling with two threads together.

Finishing. When cotton cloth comes from the loom, with the exception of coarse, unbleached muslins, it is by no means ready for the market. If the yarn has been bleached and dyed before weaving, then the cloth must be inspected, mended if necessary, knots cut off, and the fuzzy ends singed off from the surface by passing rapidly

through a gas flame. It must then be soaped and washed, starched, and finished by heavy pressing in a mangle or by a calender. The calender is a heavy pressing machine used to give smoothness and luster. A variety of finishes may be produced by the calender, the construction of the rolls through which the cloth passes, the pressure, the friction, the temperature, and the starch, all having their part in determining the finish. Winding and measuring finally prepare the cloth for market.

Cotton which goes to the market in the "brown" state goes through but one process of finishing, namely, brushing. The brushing machine is a combination of emery rolls, card rolls, and beaters, which remove the motes, knots, nubs, lint, dirt, etc., from the cloth.

If the yarn has not been bleached and dyed before weaving, this is done before starching and pressing the finished cloth.

Printing is the process of stamping a design on the surface of the cloth, or on the warp, before weaving. The processes of bleaching, dyeing, and printing will be described in a separate chapter. Printing is used for the production of calicoes, percales, dimities, organdies, and many other figured cotton cloths. Dyeing in the yarn is used for ginghams, and dyeing in the piece may be used for materials which are a solid color in the finished state.

This is but a brief sketch of the processes in the manufacture of a plain piece of cotton cloth. Corduroys, crêpes, flannelettes, and dozens of other kinds of material are much more complicated in weave and finish. Further particulars may be had by consulting reference books, if

it is not possible to visit mills, where the process may be much more easily understood.

It will readily be seen that because of the cheapness of the cotton fiber it will not be adulterated with woolen, silk, or linen; jute and hemp, while cheap, are not suitable for such adulteration. The points which the buyer must consider are the adulteration with starch, the finish which may wash off, and the color, design, and quality of the material.

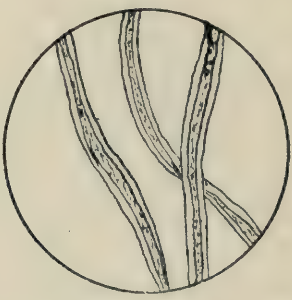

FIG. 19.—MERCERIZED COTTON FIBERS

Mercerized Cotton is a comparatively recent product put upon the market. In 1844, John Mercer discovered that by treating the cotton fiber first with alkali, then tension and rinsing with water, the fiber swelled, straightened out, and gained much in luster; it also gained something in strength and in its power to absorb dyes. It is only within the last fifteen years or so that this process has been used commercially, but the manufacture of mercerized cotton is now a very important part of the cotton industry.

Caustic soda is the alkali used, and the process

should be carried on away from the air, either at room temperature or artificially cooled. The tension may be applied during the treatment with alkali or later, but must be applied when the cotton is rinsed, otherwise the fiber shrinks and becomes transversely wrinkled. The physical change is merely straightening the twist of the cotton and swelling the fiber so that it becomes very smooth and reflects light, thus giving it luster. The chemical change is first from cellulose to alkali cellulose, then to cellulose hydrate. The mercerization is lasting, and is not removed by washing. An artificial luster may be obtained by heavy calendering, but this is not lasting. Mercerization may be accomplished in the yarn or in the woven cloth. It is probably more complete when done in the yarn, because of more even tension.

Mercerized cotton should command a higher price than ordinary cotton because it has an increased value and is more expensive to produce; therefore one should be sure that cotton is really mercerized and not merely calendered to give it the appearance of mercerized cotton. The use of mercerizing has broadened the field of usefulness of cotton and added new materials of increased beauty and serviceability to the many varieties of cotton cloth already on the market.

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CHAPTER V

WOOL

ORIGIN. The most important fiber of animal origin is the wool of the domestic sheep. There are many animals whose hairy coverings are used for textile fabrics, but the sheep furnishes the most typical wool fiber. The alpaca, vicuña, llama, camel, angora goat, are some of the other animals which produce valuable fibers. To these may be added the rabbit, beaver, and other fur-bearing animals.

History. The use of wool for spinning and weaving reaches far back into prehistoric times. Just when or how man discovered the possibility of spinning we do not know. The bones of the sheep are often found with the bones of prehistoric man, showing that it was early a domestic animal; and it seems probable that because of its easy adaptability to spinning, wool was the first fiber so used. Also, because man doubtless used the skins of animals for clothing, the matting of the fibers on the pelt might well have suggested the use of the fibers without the skin. Certain authorities, however, hold that wool spinning began with the Egyptians, and that they first spun flax; therefore, when they began to spin wool after the manner of flax they produced the smooth, even thread later known as worsted, rather than the fuzzy thread of woolen. The Egyptians perhaps used flax first, but this would not seem to prove that all races did;

nor can it be proved that the Egyptians were the first people to spin wool, although as far as can be discovered the textile arts reached in Egypt the highest development at so early a period.

Sheep belong to the order Ruminantia, class Ovidæ, and there are many varieties. Cultivation has improved the character of the fiber, which is of two kinds: true wool, which is soft and curly; and hair, usually longer and stiff. The distinction between wool and hair and the different kinds of wool will be discussed more fully later.

Sheep are indigenous to almost all parts of the world, and the spinning of woolen yarn has been carried on by primitive people in a great many different countries. In history we find mention of the woolen industry from earliest Bible times. "The oldest authentic references available to us in regard to spinning and weaving are those in the Book of Job and in the Book of Exodus, which date from about 1600 years B.C."[1]

Pure white wool formed part of the commerce of Tyre, where it was dyed purple. White wool formed the tunic and the toga, as well as other garments, of the Roman, and many of the beautiful tapestries of the Middle Ages were of woolen yarn. The growth of the industry was gradual throughout the world up to the time of the Industrial Revolution, in the last half of the eighteenth century. The history of the development of the woolen industry and trade and of the machines invented for handling it is a long one, and has been written many times.

[1] Priestman. Principles of Woolen Spinning, p. 2.

Distribution of the Industry. At the present time wool is raised in almost every country in the world, although grown only in small amounts in some countries. Australia, Argentina, and the United States lead in wool production, while Russia, New Zealand, the United Kingdom, the Ottoman Empire,[1] and other countries follow. Although it is possible to raise wool in most climates or on almost any soil, the quality of the fleece is affected by these conditions, and better wool is produced in some regions than in others.

Varieties. As has already been said, there are many kinds of wool, differing according to breed, climate, food, care, soil, and the health of the animal. Differences in some of these factors produce great differences in the same breed of sheep, or other differences produce great variation under the same climatic conditions. For centuries the Spanish Merino produced the finest wool, and so jealous were the Spanish people of their supremacy in wool that a law prohibited the exportation of Merino sheep from the country. In 1550 some sheep were taken to Peru and thence to the Argentine Republic, but they deteriorated; between 1760 and 1840 Merino sheep were carried to the other countries of Europe.

Australia has proved one of the best countries for the production of a fine, crimpy wool. There the Spanish Merino has been crossed with English breeds. By careful selection and cultivation great changes may be made in the character of the wool. The wild sheep in mountainous regions usually have a great deal of coarse

[1] According to Report of the United States Tariff Board, based on 1909 statistics.

hair mixed with the wool, while the most improved varieties on pasture land have practically no hair. The amount of imperfectly developed wool is also greater in uncultivated sheep.

Marked difference is found in the qualities of wool from the same fleece. The fiber from about the hind legs and tail is coarse, strong, and frequently dirty; the

FIG. 20.—GRADES OF WOOL

A. Best quality wool B. Second quality C. Poorest wool

neck has short wool, but fine, and there is apt to be poorly developed wool here; on the lower part of the neck, in front of the legs, the wool is worn; and low down, near the legs, it is especially bad, since it is usually mixed with hair. The shoulders and sides furnish the best grade of wool, while that of the back is somewhat inferior. (See Figure 20.) There is greater variation on some sheep than on others, and the best qual-

ity of one breed may be much better than the best quality of another breed.

Cultivation. The cultivation of sheep for wool consists in keeping the animal in the most healthy condition possible, in careful breeding, and in shelter from the worst rainstorms. Care must be exercised to protect the sheep from parasites, or they must be dipped with preparations which destroy the parasite. The sheep must also be kept as free as possible from burrs and other vegetable matter, which decrease the value of the wool.

Importance of the Industry. Among textile industries, wool is second only to cotton in importance. Before the Industrial Revolution wool was most important, but the ease of preparation of cotton by machinery and the cheapness of production have placed it in the front rank. In the United States wool manufacture, as well as wool culture, is an important industry, but a large amount of raw material, cloth and yarns, is annually imported. The manufacture is largely concentrated in the New England and Middle Atlantic states, especially in Massachusetts, Rhode Island, and Eastern Pennsylvania, although there are many mills in other parts of the country.

Chemical Structure and Properties. Turning to the study of the individual fiber, we find that it has very important physical and chemical properties, which play a large part in determining how it is to be treated in manufacture.

Chemically wool is a protein substance, composed of carbon, hydrogen, oxygen, sulphur, nitrogen, and phosphorus. Nitrogen may be detected by charring wool

with caustic potash, when an odor of ammonia is given off. When distilled by itself, hydrogen sulphide may be detected in the fumes.

In raw wool there is a large percentage of foreign substance, dirt, and products secreted by the skin of the animal. The natural oil secreted keeps the fiber in a soft condition, and must not be entirely removed before manufacture. Different compositions are given for raw wools, the impurities varying from fifty to eighty per cent of the weight of the fleece.

Matthews classifies these impurities as follows:[1]

a. Grease or wool fat.

b. Suint or dried-up perspiration.

c. Dirt, consisting of dust, sand, burrs, etc.

Suint, or yolk, is a secretion from the skin of the sheep; it is soluble in water and contains potash salts of fatty acids. This suint coats the fibers when they are on the back of the animal, and prevents them from felting. It also keeps them soft after shearing.

Strong alkali removes all oil, making the wool harsh, and also destroys the fiber if its action is allowed to proceed far enough. Five per cent caustic soda dissolves wool at boiling temperature in ten minutes. On the other hand, dilute mineral acids have no injurious effect, and the most concentrated acids dissolve wool only when heated.

It is possible to mercerize wool with caustic alkali, and the mercerization is more effective if glycerol is present. The wool becomes strong and more lustrous, both qualities probably being due to the fusion of the

[1] Laboratory Manual of Dyeing and Textile Chemistry, p. 15.

scales on the surface of the fibers, which present a more continuous reflecting surface and are not so easily pulled apart. Mercerized wool is not used much for commercial purposes. An increased luster may be given to wool by the action of chlorine, a process that is used commercially. Both these changes increase the affinity of the fiber for dyestuffs and also destroy the felting property. Novel effects are produced in cloth by the combination of chlorinated with unchlorinated wool, the two differing in the amount of dye taken up and also in the amount of shrinking and felting.

Lime has a deleterious effect on wool, making it harsh and brittle. Therefore, when wool is pulled from the skins of dead animals, as is sometimes the case, lime being put on the back of the skin to loosen the wool, great care must be taken that no lime remains in the wool.

Water at 130° C. under pressure disorganizes the fiber, and at a higher temperature dissolves it completely.

Wool is bleached with the fumes of sulphur or with hydrogen peroxide. The latter process is, however, too expensive for wide application. The affinity of the animal fibers for dyestuffs is much greater than that of the vegetable fibers. Wool may be dyed in many dyestuffs without the use of an assistant, and the color is quite lasting.

Physical Structure and Properties. Physically the wool fiber is a complex arrangement of cells. An inner or medullary layer, containing the natural pigment, may or may not be present; in highest bred, pure white wool they are lacking. The cortical layer gives the fiber its

strength and also absorbs dyestuffs, while the outside layer of horny scales, generally overlapping each other and projecting out from the surface of the fiber to a greater or less extent, gives it that characteristic peculiar to wool, the property which the fibers have of felting together, so that cloth may be made without spinning or weaving. These serrations produced on the surface of the fiber hook into each other, especially when the fiber is warm and moist and the scales open more; then when dry again they hold fast together. To this property the shrinking of wool is also due.

The difference between hair and wool is largely in this layer of horny scales. On hair they are much less marked, and often do not project at all at the edges. The internal structure of the two varies so in different varieties of each that it is hard to make a distinction; in fact, some wools are so similar to hairs that it is difficult to distinguish between the two.

Between hair and wool are a number of fibers varying in the number of scales and the amount of projection. Among these are alpaca, llama, camel, and others already mentioned. The distinction is sometimes made that hair is straight and wool is curly, or that hair is stiffer than wool; but here again the difference is sometimes greater between the extremes of wool or the extremes of hairs than between a given wool and a given hair.

The microscopic structure of the wool fiber serves to distinguish it from all other textile fibers, as well as to distinguish the different kinds of wool from each other.

The amount of luster which wool has also depends on the scales. If the edges of the scales are rough and uneven, the fiber as a whole will not be as smooth and lustrous as a fiber in which the scales are more regular and reflect the light evenly. The fiber from the Angora goat, which has less prominent scales, has greater luster than the wool from most sheep, but there is also great variation in different breeds of sheep.

In certain classes of sheep, or on fleeces which have had very hard wear, fibers often lack part of this surface layer of cells, are irregular in size or even may be bent at an angle, lack strength, and are therefore not as valuable as the perfect fibers. They lack luster usually, cause trouble in manufacture, and do not always take dye, and so make a streak in the finished cloth. These fibers are called kemps.

In tensile strength and elasticity wool fibers vary greatly. The structure of the fiber makes it elastic and also gives it strength. The kinky nature of the wool also makes it elastic. In its hygroscopic property, or power to absorb water, wool stands first among fibers, being able to absorb within itself as much as fifty per cent of water without appearing wet, although the average amount of moisture absorbed is twelve to fourteen per cent. In European and English markets sixteen to nineteen per cent of water is usually allowed in wool. This percentage varies with the form of the wool, whether loose, combed, yarns, etc. The price is regulated according to the percentage of water. So important is this percentage of water to the buyer that there are condition-

ing houses whose business it is to determine the amount of water in samples of wool.

Preparation for Market. The woolgrower, when the proper season of the year has arrived, gathers his flocks for shearing. The time varies in different climates, but is in the spring when the sheep no longer needs its wool for warmth. Different practices are employed in shearing; sometimes the sheep are washed in a running stream and then shut in a pen until they are thoroughly dried, or turned onto clean grass or straw, but more often they are not washed at all. The manufacturer often prefers unwashed pelts, because washing removes the suint; and unless the sheep are allowed to run long enough after the process to excrete more of this substance, the wool becomes harsh. There is also danger of felting the wool if there is any rubbing; therefore washing in running water is better than any other, since it carries off the dirt more easily and provides a constant supply of clear water.

Shearing consists in removing with shears the entire fleece of the sheep in one continuous sheet. Often the shearing is done by a machine, which gives rather better results than hand shearing, as it is more even. The pelt or fleece from each sheep is rolled into a compact bundle, and here again care must be taken that no dirt or vegetable matter is rolled up with the wool. The sheep should be sheared in a place free from straw, and no vegetable fiber cord should be used in tying the bundles, as it may become mixed with the wool and cause difficulty later. The single fleeces are combined into bags or bales and sent to market.

Points in Buying. In buying wool the following points are among those considered: fineness, evenness, quality of scale, color, strength, length, softness, and amount of moisture.

Sorting. The first process after the wool reaches the manufacturer is opening and sorting the bales of fleeces. The task of the woolsorter is not the most pleasant. In the first place the fleeces are very dirty and odorous and, more serious still, often contain anthrax germs, which produce the disease commonly known as woolsorter's disease, with sometimes fatal results. To lessen the danger of contracting anthrax the best factories provide screens on the top of a duct, through which air is sucked. The expert woolsorter unrolls his fleece on top of this screen. The dust and germs are drawn down together as he rapidly separates the wool into the different grades, putting each grade into a basket provided for it.

Scouring. The wool must next be freed from the large percentage of different impurities present. Dirt and animal matter from the ground, vegetable matter, burrs, leaves, sticks, etc., and the various excretions of the skin of the sheep are matted into the fleece. Several processes are necessary to remove these different impurities. First, the wool is washed. This opens the little scales of the woolen fibers, and allows them to shake apart and spread out. Hot water makes the wool harsh, so a moderate temperature must be maintained. Soap is used to remove the grease and dirt, but here again care must be used, for strong free alkali injures the wool. The alkaline carbonates seem to be best suited

for scouring, as at moderate temperatures they do not appear to harm the wool.

Soft water is necessary for successful washing, and if only hard water is attainable it must be softened or have the lime precipitated by caustic soda. A soft potash soap should then be used, and in the last waters this soap should be neutral.

The wool is washed by being moved slowly through long troughs containing the water, soap, and carbonate. It is then squeezed through rollers.

The wash water contains valuable potash from the suint of the wool, and also oil and other substances, which are extracted for fertilizer and various purposes.

Drying. The wool must next be dried. Here again care must be used. Wool dried by artificial heat too rapidly is harsh. The best methods are either to lay the wool on a netting and blow heated air up through it or, better still, to dry it in a hydro-extractor, which, revolving at a high speed, forces the water out at the sides.

Carbonization is the process used to remove the vegetable impurities which do not come out in the scouring. These burrs, etc., stick so closely to the wool that the best method for removing them seems to be to destroy the vegetable matter completely by a chemical which does not harm the wool. Ordinarily the wool is saturated with dilute sulphuric acid, which is then dried. The drying process removes the water from the acid, which then takes up the water of the vegetable matter, thus disintegrating it. As the burrs, etc., then fall to pieces, a dusting process removes the pieces; the wash-

ing which the wool must undergo to remove the acid also removes the burrs.

The burring machine sometimes removes the burrs by a mechanical process, but this is not so satisfactory as carbonization.

When the wool has been washed thoroughly, dried, and carbonized, so much of the natural oil has been removed that if it is to be soft some oil must be returned before the succeeding processes are carried on. The best grades of oil are used for wool to be made into worsted yarns, as the oil remains in them longer; in woolen, however, it is all washed out in the milling processes; therefore cheaper oils may be used. The wool has now been converted from a dirty, oily, compact mass into a loose, fluffy, white pile, with comparatively little impurity, although still much tangled. The next step must be to convert this tangled mass into even, fine threads. Here the process is divided, first, into the making of woolen yarn; second, into the making of worsted yarn.

Woolen and Worsted. Various distinctions are given between these two yarns; viz., that woolen is made from short wool and worsted from long wool, and that woolen is carded and worsted combed. While both these statements are to a certain extent true, the real distinction lies in the fact that woolen thread has is fibers running in many directions, more or less tangled, while worsted thread has its fibers quite parallel. Since woolen cloths are quite largely felted, this crisscrossing in every direction leaves many loose ends of fibers exposed on the surface to mat together and form a

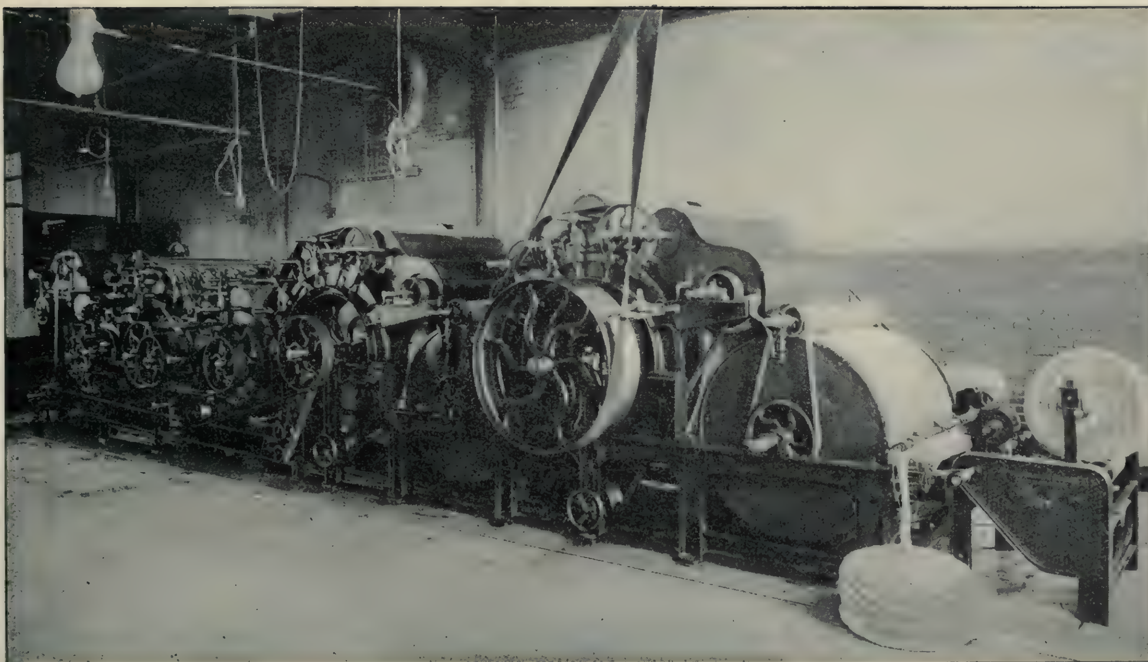

FIG. 21. — WORSTED CARDING

compact material. Worsted, on the other hand, usually shows the threads of the weave, and therefore needs to have the ends of the threads held in place, so not to produce a felted or rough surface. The short fibers seem best suited for woolen and the longer fibers for worsted. The processes used to bring about these two results are quite different.

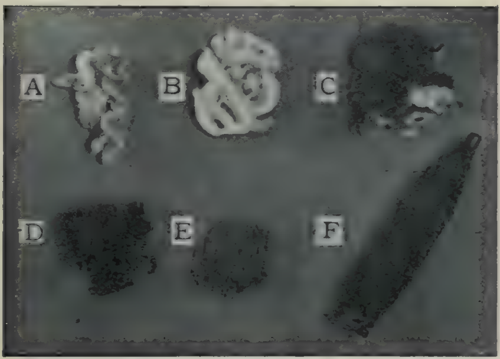

FIG. 22.—PROCESS IN WOOLEN MANUFACTURE

A. Wool from sheep's back B. Scoured wool C. Dyed in raw state
D, E. Carded F. Spun

Woolen Yarns. In making woolen yarn, the fewest processes by which it is possible to get the fiber into the form of yarn are used. There are, perhaps, two sets of carding machines; and as the sliver from the first card is fed into the second it is fed sidewise, thus keeping the fibers more entangled than if it was put in lengthwise. The second carder feeds to the condenser, which delivers a soft, small rope ready to be spun. The principle of the wool-carding machine is like that of the cotton card; series of bristles mounted in rollers and

leathern aprons brush the fibers out smooth and somewhat parallel, and form them into a thin sheet. The condenser takes the sheet from the last card and separates it into a number of small rovings or ropes, ready for the mule spinner.

Spinning. The mule is especially suited to spinning woolen. In it the thread is drawn out to a distance of about two yards, the revolving bobbin twists it, then the thread is wound on the bobbin.

Fancy Yarns. Different sorts of fancy woolen yarns may be made by twisting two yarns together or by winding one yarn irregularly about another, and by other methods. Colors may be varied by dyeing the wool before it is carded, or by mixing different colored wools before they are carded, large, thin sheets of one color being spread on top of another, sprinkled with oil, and then the whole put through the carding machines. Irregular twists or combinations of cotton or silk, twisted with wool, give variety in yarn.

Worsted Yarns. As has been said, in worsted thread all the fibers are laid as nearly parallel as possible; therefore, all the processes in its preparation for spinning have as their object this straightening out of the fibers. Not all worsteds are alike, but are usually divided into three classes, the first and finest class requiring most processes and being most parallel, the next not quite so even, and the third class of carpet yarns being least parallel.

The processes by which the desired results are obtained vary with different wools. Short wools are carded, as for woolen yarns, care being used to place the

fibers as much in one direction as possible. The speed of the cards must be regulated to prevent tearing the wool, and when the process is complete the wool is removed from the card in a soft, untwisted rope, similar

FIG. 23.—PROCESS IN WORSTED MANUFACTURE

1. Unwashed wool **2. Scoured and picked** **3. Carded** **4-7. Combed** **8-18. Stages of drawing**

to the sliver from the cotton card. Another preparatory process, and the one commonly used for long wools, consists in passing through a set of gill boxes, whose function is as follows: "Their task is to comb and straighten out the wool without definitely removing the short fibers, and their working parts are fairly simple. There are two pairs of horizontal rollers, and between them a number of actual combs, their teeth in a vertical position. The trade does not use the word comb in this

connection, but it applies strictly. Faller is the technical term, a word which describes the motion rather than the character of these combs, for each in turn moves forward along a pair of screws, with and through the wool, falls as it reaches the second pair of rollers, is carried back on a low level pair of screws, raised by a lever to its former position, and so *da capo.* Before entering the first pair of rollers the locks of wool are laid parallel and roughly straightened by hand. As the fallers move faster than the front rollers, and the back rollers faster than the fallers, the wool is at the same time dragged straight and combed straight. The boxes are of course graduated: in the first there may be two pins to an inch on the fallers; the last has fourteen to sixteen. Long wool usually goes through half a dozen boxes, is then washed, oiled again, and put through at least two more boxes before it is sent to be combed, in the technical sense of the word. The slivers are joined together and drawn out, finer than before, again and again during the process, so that the last sliver of all is sure to be uniform in structure from end to end." [1]

It is difficult to understand these different operations without having the machine before one, but the whole principle of the gill boxes is to comb the threads more and more parallel, to draw them out into more even strands.

The combing proper which follows, besides completing this process of straightening, removes the short fibers, or, as is usually stated, separates the long fibers, or "tops," from the short ones, or "noil." The combing

[1] Clapham. The Woolen and Worsted Industries, p. 39.

machine is a very complicated one, and no effort will be made here to describe it. The fibers are caught in the teeth of a revolving circle of metal, from which they are removed by rollers set too far apart to catch the short fibers which drop out. The comb is heated, since the wool seems to work better when warmed.

Before the spinning the wool must go through two or three more gill boxes and then be drawn. Drawing is a simple process by which two or more slivers of wool are put through two sets of rollers, the second revolving faster than the first. These draw out the strand until the resulting sliver is smaller than either original one. This process is repeated again and again, the sliver becoming smaller and smaller, and during the last few processes a slight twist is given to it. Spinning then serves to impart a final twist and the worsted yarn is ready for use.

This process is the one used for the best worsted yarns. Those which are made from shorter wools, carded, are put through two or three gill boxes, combed, then drawn and spun, while the carpet yarns and coarse knitting yarns are merely carded. These distinctions are not always exact, as two kinds may be combined, but in general these are the three processes for the different worsteds.

The spinning of woolens and worsteds does not differ greatly. The mule used commonly for woolen is sometimes used for worsted also, although the use of the flyer frame for worsteds is more general.

Weaving is now a purely automatic process. The loom has only to be threaded with the warp, the smooth bobbins wound with filling, and the machinery set in

motion. The whole process is marvelous to watch. This automaton is the result of the perfection of inventions, of many centuries of human skill, and of comparatively few years of invention of mechanical devices. Only the tying of broken threads, the putting in of yarn, and the taking out of the cloth must be done by hand.

Finishing. The cloth which comes from the loom is far from being a finished product; in fact, so much is yet to be done that there are establishments whose only business is finishing woolen and worsted cloth. These finishing processes convert a coarse, rough, dull-looking material into our most beautiful broadcloths or worsted suitings.

Here again a distinction must be made between woolens and worsteds, for their surface is as different as the thread from which they are made. Woolen with fibers crossed in many directions in its threads may have the ends of these fibers raised on the surface, matted together, sheared, pressed, until the threads of the weave are completely hidden by the felted surface. Worsted, on the other hand, has gone through a long series of processes in order that it may be a smooth, regular, and perfect thread which weaves into a firm, regular cloth. Therefore its surface shows each thread, and any finishing process has for its object polishing and bringing out the individual threads. For this same reason variety and interest are given to the different kinds of worsted cloths by carefully worked out diagonal and pattern weaves, while woolen is ordinarily woven with a plain weave. When the cloth comes from the loom it must be thoroughly examined, defective places darned

if necessary, knots tied, and ends cut off. All woolens, as well as worsteds, when they come from the loom need to be thoroughly washed. Washing has more than one purpose; it not only removes the oil and dirt gathered in the mills, but also shrinks the cloth. Shrinking is increased by the application of heat and pressure, especially pressure exerted with a rubbing motion from side to side. Such a process is employed in finishing woolens and is known as milling or fulling, and produces a very close, compact surface.

Teasling, so called because of a small vegetable cone or teasle most commonly used in the process, consists in picking up the nap of the surface loose ends. This nap is then brushed, sheared, pressed, polished, steamed, and given various treatments to increase its luster, its evenness, and its smoothness. In some materials whose finished surface is rough, most of these processes of brushing, steaming, pressing, etc., which follow teasling are omitted and the nap is left uneven.

When the material has been felted, had its surface raised, and other modifications in its original texture have been made, it is prepared for the market by a stretching process known as tentering. The cloth is stretched to a uniform width on tenter hooks arranged in rows on beams, which may be adjusted to the desired width of the cloth.

A final light sizing and pressing prepare the cloth for folding, baling, and sending to the wholesale dealer.

The felted surface which is given to woolen affords excellent opportunity for adulteration, cotton or other fibers being easily concealed beneath the wool.

Mohair. Mohair is a material made from the long, lustrous hair of the Angora goat, and is woven usually with a cotton or silk warp. It furnishes a smooth, hard-surfaced material, which wears well, sheds the dirt, and is inexpensive. Alpaca, which somewhat resembles mohair, is made from the wool of the domesticated alpaca, and is stiffer than mohair.

Made-over Wool. Aside from the different varieties of wool used for cloth, and the adulteration of wool by cotton or by sizing, there are certain wool substitutes whose use has grown very rapidly in the last generation. These substitutes are classed under the name shoddy. The term shoddy has come to be applied to any inferior goods or material which pretends to be better than it is. Technically speaking, however, shoddy means made-over wool, and more strictly one particular grade of made-over wool.

For a hundred years the manufacturer has made cloth, either entirely or partially, from old rags pulled apart, respun, and rewoven into cloth. The industry has grown steadily, and the proportion of shoddy to the new wool produced has increased until now it is about one-third as great as the new wool industry.

The rags bought up by the rag man are sent to the larger rag dealer, then to the shoddy manufacturer. Here they are sorted into different grades according to composition, all wool or mixed goods, according to color and to quality. These rags are then dusted, washed, and pulled to pieces by rollers set with teeth.

Shoddy. Fibers from worsted rags or knit goods are longest and best and are called shoddy. They may

be mixed with new wool or with cotton and woven into new cloth, or they may be woven alone.

Mungo. Fibers from woolen cloth that has been felted are naturally shorter and more broken when separated, and make an inferior grade of material, known as mungo.

Extract. Rags which contain a mixture of cotton and wool have the cotton separated out by a process of carbonization. The rags are treated with dilute acid, usually sulphuric, dried, crushed to destroy the weakened fibers, neutralized, and dried. The rags are then torn to pieces to produce a grade of fibers known as extract.

Flocks. The last and poorest class of shoddy, called flocks, consists of shearings from woolen cloth and shreds of wool rags. These are too short to weave alone, but may be felted into the surface of woolen cloth to add weight.

Spinning and weaving shoddy, mungo, or extract does not differ from other woolen spinning, except that the poorer grades of shoddy, and practically all mungo and extract, must be mixed with a longer fiber, either wool or cotton, in order that it may be spun.

The especial value of shoddy lies in the fact that it has greatly increased the supply of woolen cloth on the market, thereby reducing the cost of good wool, as well as providing a cheap wool. It brings woolen cloth within the reach of many who could not otherwise afford it. While ordinarily material made up entirely or in part from shoddy has not the wearing quality of new wool, it has warmth, and the best grade may be even better than the poorest grade of new wool.

Microscopically, shoddy may be distinguished from new wool in that the fibers are not as uniform in size or general character. The color of the different fibers often varies considerably, the ends may be broken and uneven, and often the scales are gone in parts of the fiber. Cotton fibers are not infrequently found with shoddy.

Some shoddy is longer than the shortest wool, so the length of the fiber is not a true test. The poorer grades of shoddy will make a thread which breaks easily, like rotten string. One needs to guard against this grade if durability in the finished cloth is a consideration.

The fibers called flocks, felted into the surface of cloth, rub out after some wear, collecting in the linings of coats, the hems of dresses, etc., and leaving the surface of the cloth threadbare.

Felt. Woolen fibers, because of their ability to hold together, may be made into cloth without the processes of spinning and weaving.

The wool used to make felt is cleaned, then carded into sheets several feet wide and very thin. These sheets are put one on top of another until the pile is about one inch thick, and are then passed through a series of rollers submerged in water. One roller is of wood, the other of tin filled with steam. The motion of the rollers is from side to side, as well as revolving, and the combined action of heat, moisture, and pressure opens the scales of the wool, tangles and mats it until felt is the result. This material is then dyed or printed, if so desired, is tentered and pressed, and then goes to the market.

Hair and cotton may be mixed with wool in limited quantities. This is done either before carding, as in case of cotton, or layers of hair may be mixed with the layers of wool, and the whole felted.

By these varied processes the dirty mass of wool which comes to the factory is transformed into many kinds of cloth to suit the needs and demands of a novelty-loving public.

With the changes in conditions of living, with warm houses, overheated public buildings, cars, trains, etc., the requirement for woolen underclothing has decreased. Although cotton, linen, and silk have replaced wool in many uses, for some purposes it is almost indispensable. For use in babies' flannels, underclothing for men working in places of extreme heat or cold, for protection from the wind, and for many other purposes, wool is the best material known, and the demand for it increases continually.

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CHAPTER VI

SILK

WE now have to deal with a fiber which is very different in structure and physical characteristics from any other of those commonly used. In origin, although an animal fiber, silk differs from wool and hair in being the secretion of an internal gland of the silkworm, while wool is an epidermal appendage. Other worms and spiders produce a similar secretion, but only the silkworm has furnished us with a fiber strong enough to be spun into thread and of such a nature that it is prized above all other textile materials.

History. The use of silk by man does not, like the other textile industries, date back before the dawn of history. It has been a comparatively recent development. Chinese records tell us that in 2700 B.C. the Empress Se-ling-chi investigated the silkworm cocoon, reeled the silk filament from it, spun thread, and had it woven into garments. For many hundreds of years the Chinese carefully guarded their secret. At first only the royal family carried on the industry, but gradually it spread and became national. Chinese silks were carried all over Asia, but the process of making them was still kept secret, while to carry the eggs of the silkworm out of the country was punishable by death. As a result, although silk of some other varieties was produced in neighboring countries of the Far East by carding the

fibers from the cocoon, it was not until about the fifth century A.D. that the process of reeling was known outside of China.

The Emperor Justinian, 555 A.D., is said to have bribed two Nestorian monks to bring some silkworm eggs from China. They accomplished this by concealing the eggs in the hollows of their bamboo staffs. Silk culture in the Levant dates from about this time. Through the Moors sericulture was brought into Spain about the ninth century, and by the twelfth century it had reached Italy, where it gradually developed until it became a national industry. France began sericulture during the thirteenth century, and in the sixteenth century some Flemish weavers brought the industry to Spitalfields in London. It was encouraged by royalty in both England and France, but the culture in England has never been very successful. Thus it was more than four thousand years from the time silk reeling was first discovered until it had spread over Europe. Silk fabrics, however, were an important article of commerce as early as in the days of the Roman Empire.

In 1838 Mr. Samuel Whitmarsh introduced sericulture to America, and repeated efforts have been made by individuals and by the government to encourage the industry in various parts of this country, but none of these have met with any marked success. Beginnings were made in Connecticut and Pennsylvania, but both these enterprises were cut short by the untimely freezing of the mulberry trees upon which the silkworm feeds. A recent attempt in Utah is proving unsuccessful because of a lack of skilled labor to reel the cocoons. The hope

that communities where the women and children have no employment might take up this industry to increase their incomes seems to be vain. The greatest difficulty, apparently, is in the reeling of the cocoons. That this is not the only difficulty is shown by the fact that even when the government set up a filature to carry on this work, the returns from the silkgrowers were very small. The cheapness of labor in silk-producing countries makes it apparently impossible for the United States to compete in this part of the industry. Better organization and more skilled labor might lessen the difficulty, but since the silk is of rather inferior quality, and has been produced at a cost of four or five dollars a pound, while imported raw silk can be bought for from four to eleven dollars a pound, the outlook is not encouraging. It should be noted, however, that at the present time one-third of all the silk cloth manufactured in the world is made in this country from raw silk imported from southern Europe and Asia.

Present Industry. The countries in which silkworm cultivation is most successful are Italy, France, Spain, Austria, China, Japan, and India. The French and Italian silks are better reeled than much of the Chinese and Japanese, as these countries do not always use the most improved machines.

There are two distinct types of silk produced, that from the cultivated silkworm, or *Bombyx Mori,* carefully reared and fed on the leaves of the white mulberry tree, and that from several varieties of wild silkworms which are not carefully reared and which feed on other kinds of trees. The cultivated silk is as a rule finer and more even

than the wild, and may be much more readily spun from the cocoon. The wild silks, however, furnish an attractive variety of fabric, commonly known as pongee or tussur. Japan, China, and India all produce these wild silks.

The silk industry, although not nearly so large as the cotton or woolen industries, is important, in that it provides us with a beautiful fiber which has been unequaled in fineness, luster, and strength. As has been said, this industry is most successful where labor is very cheap, because of the large amount of hand work required in the culture of the worms and in the reeling of the silk from the cocoons. Necessarily, the cultivation is restricted to countries where the mulberry tree will flourish.

Physical and Chemical Structure and Characteristics. As an animal fiber, silk has some characteristics resembling wool, but in its physical structure it is very different. While wool consists of layers of cells of different kinds, silk has no cell structure. The length of the silk fiber makes it unlike any other. A carefully reeled fiber from a perfect cocoon may be from three to four thousand feet long. In evenness, strength, and fineness the fiber will differ slightly in different parts of the cocoon, the best part being in the center. The first silk reeled from the cocoon, together with the innermost layers, is less strong and even, and somewhat finer.

The pure silk fiber is transparent and lustrous, but as it comes from the cocoon it is covered with a coating of gum, which conceals the luster shown by the fiber when the gum has been removed. Pure silk is very

strong, being sometimes compared to an iron wire of the same diameter. It is also very elastic.

Scroop is the term applied to the rustle peculiar to silk, but is not a quality inherent in the fiber. Scroop is produced by treatment with dilute acid, acetic or tartaric, which is allowed to dry on the surface of the silk.

The hygroscopic power of silk is high; 30 per cent of water may be taken up and a great amount of dye-

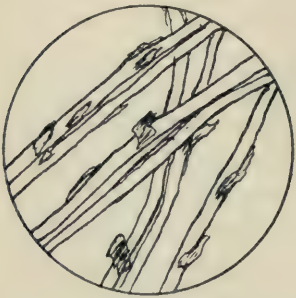

FIG. 24. — RAW SILK FIBER, GUM ADHERING

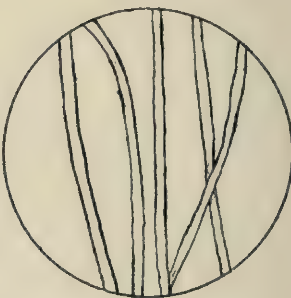

FIG. 25. — SILK FIBER, GUM BOILED OFF

stuff and metallic salts may be absorbed without in any degree changing the appearance of the silk. This property is made use of in adulteration by the process of weighting, when a large amount of foreign matter, mineral salts and dyes, is added to the silk. In the case of heavy fringes as much as 200 to 300 per cent of the weight of the fiber is sometimes added.

The microscopic appearance of cultivated or mulberry silk shows two fibers, each smooth, round, and structureless, united by the gum secreted at the same

time that the fiber is formed. There are no markings on silk from which the gum has been removed, but threads from woven cloth usually show some grains of dyestuffs or weighting material.

Wild or tussur silks are very different from cultivated silks in microscopic appearance. Instead of being round, regular fibers, they are flat and somewhat irregular. While true silk has rarely any longitudinal striations, the wild silks are quite definitely marked, the

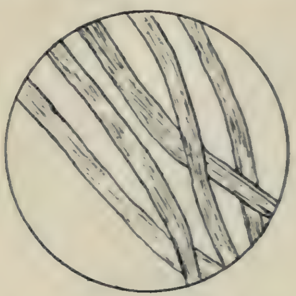

Fig. 26. — Wild Silk Fiber

fibers sometimes having a twisted appearance, while the ends often appear frayed, as if the fiber were composed of small fibrils which had begun to separate.

Chemically, silk is composed of fibroin, a protein substance differing from wool in containing no sulphur. Its reactions are similar to those of wool. Alkalies do not act as readily on silk as on wool, but when concentrated dissolve the fiber, while dilute alkalies weaken it. Concentrated mineral acids rapidly dissolve the fiber, but dilute acids have little injurious effect. Silk readily absorbs these acids from dilute solutions. Acetic and

other dilute organic acids produce the scroop, or rustle, already spoken of.

Solutions of common salt have a deleterious effect on silk, greatly weakening the fiber. In some climates, on islands in the sea, for example, silk is so weakened by the salt in the atmosphere that it drops to pieces. This action is increased when the silks have been heavily weighted. Other salts produce this same result to a certain extent, as is shown by the rotting of heavily weighted silk when laid away for some time and the weakening of silk by perspiration.

Silk has, perhaps, a greater affinity for coloring matters in general than any other fiber, and may be dyed a great number of tones and hues.

Silk Culture. The silk industry may be divided into two distinct parts, the culture of the silkworm and the manufacture of the fiber into thread and cloth.

Only one of the two types of silk mentioned, the *Bombyx Mori,* or mulberry silk, has been extensively cultivated. The wild silk cocoons are gathered from trees where the worms have spun them, and little attention is paid to the worm during its growth. The cultivation of the mulberry silkworm is, however, a delicate operation, and the value of the silk depends largely on the care and food of the worms.

The silk culture is usually carried on in rooms or sheds devoted to its use, and requires much hand labor. In July the moth lays several hundred eggs about the size of mustard seeds, which, by virtue of a gummy substance secreted with them, stick to a cloth that has been provided for this purpose. This cloth is hung up

to dry, then put away in the dark and cold until February or March, when it is brought out and hung in a warm place. In about thirty days the tiny worm, one-eighth of an inch in length, hatches; it immediately begins to eat the mulberry leaves which have been provided for it. These worms are kept on trays in a room of the right temperature, and are supplied with fresh

FIG. 27.—MULBERRY LEAF AND SILKWORM EGGS
The dark eggs are unhatched

leaves two or three times a day. The silkworm is a voracious eater and grows very rapidly. After about five or six days it molts; this process is repeated four times during the thirty to thirty-five days from the hatching of the worm to the spinning of the cocoon. At the end of this time the worm stops eating. Its length is now about three inches, but it begins to shrink and becomes almost transparent before spinning its cocoon.

From two glands, the openings of which are on either side of the mouth, a viscous substance is secreted, which hardens upon contact with the air. At the same time two other glands secrete a gummy substance which causes the two fibers to adhere. The single fiber is called brin; the double fiber, bave. As the worm spins, its head is thrown in such a way that the thread is spun in the form of a series of figure eights, this regular arrangement aiding the unwinding later on. Before spinning the cocoon proper, however, the worm fastens a few threads about itself to form a connection with the nearest twig or leaf; then the compact cocoon is spun about the worm, completely concealing it. The spinning, however, continues until the worm is well protected by its little case, when it goes into the dormant or pupa stage. If undisturbed, after a period of rest the moth emerges from the cocoon fully developed, lives long enough to mate and lay eggs, then dies. Thus the cycle of the life of the silkworm is completed—egg, worm, pupa, and moth.

The exit of the moth from the cocoon injures the value of the silk for the market, since the moth moistens the threads at one end of the cocoon and pushes its way out, entangling them in such a way as to interfere with the successful reeling of the silk. For this reason the cocoons are heated in a warm oven or steamed to kill the pupa within, enough cocoons being saved to provide moths for the next season's eggs.

During the cultivation the silkgrower must exercise great care that the worms are kept clean, that they are not crowded, that sufficient food is provided, and the

rooms kept at the proper temperature. Diseases due to irregular feeding, to germs and fungi, may reduce the production of silk enormously.

The very rapid growth of sericulture in Southern Europe during the first half of the nineteenth century led to carelessness and overcrowding, which resulted in a serious epidemic among the silkworms. In 1865 Louis Pasteur, the famous French bacteriologist, began the study of this epidemic and discovered that the disease was caused by a germ, and also that by microscopic examination and rejection of the eggs which carried the infection the disease might be avoided. This discovery was the salvation of the silk industry, not only in France and Southern Europe, but in other silk-growing countries as well. By careful selection and cultivation of the mulberry plants, breeding, microscopic inspection of the eggs, and improved methods of handling the worm the industry has increased rapidly in Southern Europe in the last half century.

Silk Reeling. The quality of raw silk as it reaches the manufacturer has been determined largely by care and skill used in reeling the silk filaments from the cocoon. The process is one which requires great patience and skill, as the requirements of a perfectly reeled thread are that it shall be even and contain no knots. Since all the cocoons do not furnish threads of exactly the same length, and the fiber varies in fineness in different parts of the cocoon, the reeler must know just when to add a new thread and just how to keep the threads even.

In the filiatures where silk is reeled hand work is

supplemented by a machine-turned reel, the basins in which the gum is softened are heated by steam, and many improvements have been made over the old processes still in use in parts of China, where the results are much inferior in quality. When the pupa of the silkworm has been killed the cocoons are sorted, and those of like fineness, color, luster, and degree of perfection are placed together. These cocoons are then plunged into a basin of warm water to soften the gum which holds the fibers together, and the outside loose fibers which cannot be reeled are removed. The reeler then takes a brush and finds the ends of the outside fibers, which are carefully unwound until one is found which is continuous. The fibers from four or five cocoons are united and passed through an agate ring. To make the fibers stick together the thread is then twisted about one coming from another ring, separated from that thread again, and passed through a second ring onto the reel. By the use of improved machines the reeler is enabled to watch several sets of cocoons at once. He must see that a broken fiber is immediately replaced by another, and when the fiber draws near the end and becomes too weak he must replace it by a better.

The skein of silk taken from the reel is twisted, and constitutes the raw silk of commerce. The individual fibers of the thread are stuck together by the silk gum; the silk is harsh, due also to the gum, but the skein is, nevertheless, beautiful. These skeins are packed into bundles called books, are baled, covered with matting, and sent to the manufacturer.

Silk Manufacture. Because of the length of the silk fiber, and the fact that it is already a thread in form, the processes which it must undergo at the factory are much more simple than those required for cotton and wool. Although there have already been four or five fibers united into one thread in reeling, this is not yet of sufficient strength for weaving, and several of these threads must be united and twisted. The processes of doubling or twisting as carried on at the factory are known as throwing.

Throwing may be divided into five processes:

Rewinding the raw silk from skeins onto bobbins or cops.

Cleaning by passing the thread through two fixed plates, so closely adjusted as to stop the machinery if there is a knot or irregularity. In some hand-reeled Chinese silks there are many of these irregularities, which must be removed, as the luster and beauty of finished silk depend on perfect evenness of thread.

Doubling, uniting threads from several bobbins to form one thread.

Spinning, giving a twist to the thread, the amount of twist varying according to the use for which the thread is designed.

Resolving silk into tram and organzine. Tram is the thread used for filling in silk cloth and consists of two or more single threads having no twist, combined and twisted just enough to hold for weaving. Organzine is the thread used for warp; and since it must be stronger than the filling in order to stand the strain of the loom, it is made up of two threads, one twisted in

one direction, the other in the other direction, and then the two twisted together. As organzine must have strength it is made from the best quality of silk, but because of the amount of twist it lacks luster. The filling thread, since it does not require such great strength, has less twist and a higher luster. Singles is the name given to a thread which has no twist, and it may be used as filling for cloth which is to be dyed in the piece.

Cleaning. The completion of the throwing process leaves the silk in a form suitable for weaving, but there is still present the silk gum, which hides the luster and makes the silk harsh. True silk fiber, or fibroin, constitutes about 60 to 70 per cent of raw silk; the other 20 to 30 per cent is sericin, or silk gum. This sericin is soluble in warm, soapy water, and must now be removed from the silk thread. The coloring matter of silk is partly in the sericin, partly in the fiber, so that the process which removes the gum also removes part of the color.

Not all silk requires the complete removal of the silk gum, but silks are classified according to the degree of cleansing.

Boiled-off silk is silk which has all of the gum removed.

Souple silk has one-sixth of the gum removed. Ecru silk has one-twelfth of the gum removed.

Boiled-off silk goes through three operations:

1. Stripping, or ungumming. In this process the silk yarn is softened in a soft-water solution of a good cocoanut or olive oil soap. The hanks are hung in vats and the

water is gradually heated to 200° F. During this treatment the silk swells, becomes sticky, and the gum washes off, leaving the fiber more glossy. One-half to one hour is the time required, after which the silk is

FIG. 28.—SILK COCOONS AND SKEINS

A. Cocoons B. Silk reeled as it comes to market C. Silk from imperfect cocoons D. Same silk as C after carding E. Skeins of silk spun from same

squeezed, rinsed in a slightly soapy bath, and put into bags of hemp or flax.

2. Boiling. The yarn is boiled for one-half hour in a 10 per cent soap solution, and is then washed well in clear water. This removes the last traces of gum.

3. Bleaching. If the silk is to be white or light in

color the natural coloring matter present in the fibroin must be removed. Treatment in a dilute bath of hydrochloric or nitric acid for about fifteen minutes, then a thorough washing and rinsing, are followed by exposure to sulphur fumes. This destroys the coloring matter, but leaves the silk harsh and rough. It must be softened by immersion in a cream of tartar solution for an hour and a half.

Silk is sometimes bleached in a solution of hydrogen peroxide or sodium peroxide. This method is more expensive than the former.

Souple silk is scoured in a bath at a lower temperature and containing less soap than that used for boiled-off silk. Only part of the gum is removed, but the fiber swells and becomes more absorbent.

Ecru silk has the coloring matter removed, but little of the gum. The process for this is much bleaching but little washing. The method used by the manufacturer to make up for the loss of weight resulting from the removal of the silk gum will be discussed later.

Weaving and Finishing. Silk weaving does not differ essentially from any other weaving. Because of the extreme fineness of the thread the loom is more difficult to set up, and must be run rather more slowly. A great variety of effects may be produced by variations of weaves. Damask, satin, velvet, different crêpes and brocades depend on the weave for their character. The Jacquard loom again offers almost endless possibilities, and the designer is ever at work to produce some new effect which will appeal to the public eye.

The finishing processes for silk differ from those used with other materials. Little washing or scrubbing is necessary, and most silks are finished almost entirely in a dry state. Washing is necessary with some silks, but those which have been heavily weighted in the yarn are not washed. Singeing in a gas flame, or shearing with a machine arranged on the same principle as the lawn mower, removes the fuzzy ends which would diminish the luster. Sizing may be sprayed upon the surface of the cloth, after which it is passed through heated cylinders to dry and to press out wrinkles. For certain surfaces the silk is pressed between layers of finishing paper; then, to take away the papery feeling, is passed between wooden rollers in which buttons are driven. Singeing and brushing, and a final tentering or stretching on rows of hooks to give the desired width, prepare the cloth for folding, measuring, and making into bolts for the market.

The finishing processes differ greatly for different varieties of goods. Silk may be dyed or printed before or after weaving, a moire effect may be produced by embossing the cloth with heavy engraved rollers, velvets must have the pile steamed, panne velvets have a special method of pressing, and many other processes give a great variety of results.

Waste or Spun Silk. Besides the best quality of cultivated silk and the wild silks, there is an inferior grade of yarn known as spun silk. In the process of silk culture it is necessary that a number of moths emerge from the cocoon to provide eggs for the next lot of worms. As has been stated, the cocoon is injured by the exit of

the moth, and cannot be used for reeled silk. In the process of reeling there is also much waste, such as the outsides of cocoons, which must be removed before the thread for reeling has been reached, defective cocoons, and the last inner layer, which cannot be successfully reeled.

Although the fibers from these forms of waste silk cannot be reeled in one continuous thread, they are, nevertheless, valuable and are not wasted. They are given quite a different treatment, however, from the perfect fibers. First, the gum is removed by thorough washing; then the tangled mass of short fibers is carded, as cotton or wool would be carded, then drawn out and spun into a thread. The resulting yarn, to distinguish it from reeled silk, is called spun silk.

Spun silk is usually not so strong as reeled silk, and is not so lustrous because of the many ends of silk projecting from the surface of the yarn and because of its harder twist. Frequently the two kinds of silk are combined in a material, the spun silk being used for the warp and the reeled silk for the filling.

Poorer grades of this silk, too short or too weak to be spun, are made into hat braids or a poor quality of dress trimmings.

Silk Substitutes. Because of the high cost and beauty of silk there have been many attempts to find substitutes for it. Efforts have been made to spin the spider's web and to use the filaments spun by other moths, but so far these have been unsuccessful. A single exception is the byssus of the shellfish, Pinna. This byssus is a tassel-like appendage by which the mussel

attaches itself to the rocks, and it may be combed out and spun into a thread which is used sometimes for gloves, purses, and other small articles. The natural color of this silk is olive green or brown.

Chemists have experimented for years to find a substitute for silk, and have produced several artificial silks from different substances. The most successful of these is Chardonnet silk, so called from the man who succeeded

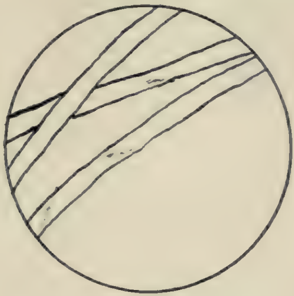

FIG. 29. — ARTIFICIAL SILK

in producing it. This silk is made from cellulose steeped in concentrated sulphuric and nitric acid and dissolved in a mixture of equal parts of alcohol and ether. This solution, collodion, is then forced through very fine capillary tubes, from which it comes in threads, which coagulate in the air. As this cellulose is highly explosive it must be denitrated before being spun into yarn.

Chardonnet silk has a high luster, considerable tensile strength, and, although yellowish in color, may be bleached with chloride of lime and dyed readily. The greatest objection to the use of it is that it does not withstand the action of water well. It is used, however,

for braids, neckties, and for fancy articles which need not come in contact with water. In making beautiful tapestries in a studio in New York, artificial silk has been found satisfactory, as resistance to water is not essential in this sort of material.

Other varieties of artificial silk have been made from solutions of cellulose in ammoniacal copper oxide, or chloride of zinc, and from filaments of gelatin treated with formaldehyde. The Chardonnet and other silks made by practically the same method are, however, most satisfactory, and have partially met an ever-increasing demand.

Thus it is that in the past two or three generations many processes have been discovered whereby the cost of silk has been decreased and the supply increased, or, rather, the supply has been made to go much farther. The unfortunate part of the change is that the wearing qualities of silk have been greatly decreased, but since the public demands quantity and variety at small cost it obtains that which it demands.

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CHAPTER VII

LINEN

LINEN or flax is the fiber obtained from the layer of bast cells just inside the outer bark of the plant *Linum usitatissimum,* or flax. The fiber is firmly attached to the woody tissue in which it lies, and it is necessary to break off the outer bark and to destroy the woody tissue in order to obtain it pure.

History. Although flax is more difficult to obtain from the plant than cotton, once separated from the stem the fibers are much more easily spun by hand methods, and it was probably the first vegetable fiber used for spinning. Just when or where linen was first used we cannot tell, but historians seem to agree that Egypt probably first discovered the value of this material. Flax is indigenous to the Nile Valley, and the earliest picture writings of Egypt show the linen industry in quite a high state of development. The Bible (Genesis 41 : 42) tells us that Pharaoh arrayed Joseph in vestures of fine linen, and more than once mentions flax in Egypt. This was about 1715 B.C. These references are to "fine linen," which shows that the industry must have been carried on for a long time, since coarse linens would be the first produced.

Mummy cloths, four thousand years old, show linen quite fine in quality. Probably very little clothing of any other material was used in Egypt until after the Christian

era. For hundreds of years the Phœnicians carried linen cloth from the Nile valley to all parts of the ancient western country. It was frequently taken to Tyre to be dyed and then traded. Purple and fine linen were symbols of royalty in the time of Solomon, and, because of its cleanliness, linen was and still is used in connection with all religious rites.

From Egypt linen culture spread to Babylon, to Greece, and to Rome. Great encouragement was given to it in Italy, and guilds were later formed to regulate and protect the linen trade. The Moors kept up the industry in Spain, and from the seventh century France and Germany were producing their own flax. Great Britain and Ireland may have borrowed the industry from the Romans. All over Europe during the Middle Ages, and until the invention of power spinning, linen was used almost entirely where we use cotton today. Although, since the industrial revolution, cotton has replaced linen for many purposes, because of the strength, luster, smoothness, snowy whiteness, and characteristic leathery texture of linen, cotton can never be as valuable, or replace it for table service and many other uses.

At the present time the linen industry flourishes, although it is not to be compared with the cotton industry. Large amounts of flax are grown in Ireland, Belgium, Holland, Germany, Russia, France, and in parts of the United States and Canada.

Physical and Chemical Structure and Characteristics. Good flax fiber, when separated from the stalk, should be from twelve to twenty inches in length, and will vary greatly in fineness. It is very strong, but has

little elasticity. Under the microscope the fiber appears straight, with longitudinal markings and, at intervals, cross markings or nodes which look almost like breaks in the fiber, and which assist somewhat in spinning, since they tend to hold the fibers together. In cross section the fiber is polygonal and has a small central canal. The fiber is composed of cells consisting of almost pure cellulose, held together by a vegetable gum or pectin, which also gives it color. This structure makes it very different from cotton, which is a single cell. The color varies from yellowish-white to brown and from pearl to steel gray, the best quality of flax being pale yellowish-white. The variation in color is due quite largely to differences in the processes of retting.

Luster is one of the most prized assets of linen and is retained as long as the fiber lasts. It may be affected by retting, as may the strength of the fiber.

Linen does not absorb a great amount of water into the fiber, 6 to 8 per cent being an average amount, although it may reach 20 per cent; neither has it a great affinity for dyestuffs or metallic salts. A certain amount of vegetable oil is present and aids in the spinning processes. Probably the failure of some chemical methods of retting is due to the fact that too much oil has been removed from the fiber. Bleaching removes this oil and also some of the vegetable waxes and gums present; therefore unbleached linen is usually stronger than bleached.

Again, because of this combination of cells, linen may not be bleached rapidly, as cotton is, by the action of hot alkalies. The fiber is disintegrated by these. Acids do

not act so rapidly on linen as on cotton, since the gums protect the cellulose and make the action slower.

The affinity for dyestuffs is not so great in linen as in cotton, again probably due to the resins uniting the cells of the fiber. Otherwise, being almost pure cellulose, it is chemically similar to cotton, especially after being bleached.

Linen is a better conductor of heat than cotton; therefore it feels cool to the touch.

Cultivation. Flax culture must be divided into two branches, culture for fiber and culture for seed. In the United States flax is raised almost entirely for the seed. Linen is woven to a certain extent in this country, but the raw material is imported and the manufacture is limited almost entirely to thread, twine, and coarse materials. Very recently a new branch of flax manufacture has been attempted, in which the broken straw, left after the removal of the seed, may be converted into yarn and woven.[1] Up to this time all straw left after the removal of the seed has been a waste product.

The flax plant requires a temperate climate, but grows in varied soils. It cannot, however, be grown for many years in succession on the same soil, but must be rotated with other crops. The best grades of flax for fiber are produced on fertile soils, in districts where the temperature is even, moist, and not too high, as in parts of Russia, the Low Countries, and Ireland. The temperature lines of this area would include Wisconsin, North Dakota, Minnesota, Iowa, and parts of Michigan, the states in which flax is grown for seed.

[1] Described more fully on p. 120.

Flaxseed must be sown in early spring in land which is rather heavy and well drained. It requires a rich soil, not because it takes more from the soil than other crops, but because, if it is to be used for fiber, it must take it quickly. The ground must be well prepared, finely broken up, the seed sown broadcast, and is best raked in by hand. When the plants are two to three inches high they must be weeded very carefully by hand. When they are nearly grown a stalk of blue flower appears, followed by the flaxseed. Before the seed is entirely ripe, and when the stalk of the plant has turned yellow about two-thirds of the way down, the flax is harvested. In most countries the harvesting time is July. The plant should be about three feet high when pulled, and must be pulled in clear, dry weather. If flax were cut as other grains are, part of the available fiber would be lost.

Separation of the Fiber. The process of separating flax fibers from the rest of the plant is a long and tedious one. The seeds and leaves are removed from the stems by a process known as rippling, the ends of the stalks being put between rollers which crush off the seeds and leaves. Next, the stems are tied in bundles and put through a process of fermentation, which loosens the bast fibers from the woody portion by decomposing the resins which unite them. This process, known as retting, may be accomplished in a number of ways. Dew retting consists in spreading the fibers on the grass and leaving them exposed to the action of dews and sun for about two weeks. This method is practiced in parts of Russia and yields a silky fiber, but it is a question if the result would not be just as good

if the same flax were retted in another way. A more common method is to put the bundles of flax into pools

FIG. 30.—FLAX

A. Michigan Flax, seeds removed B. Flax retted C. Flax scutched D. Flax hackled E. Flax drawn
The dark color of B and D is due to chemical retting

of stagnant water and allow them to remain for several days. Since gas is evolved in the process of fermenta-

tion, the bundles must be weighted down to keep them under water. Soft water gives better results than hard. A third method is that of soaking the flax in streams of running water. The famous Courtrai flax of Belgium is retted in this manner in the slow-running waters of the River Lys. Its creamy color is due probably to the soft, slow-running water, which has a peculiar ferment.

As a rule, running water gives a whiter flax than pool retting, because the water does not become so polluted. Dew retting does not produce such uniform results. Many attempts have been made to shorten the process of retting, the most successful being those in which tanks are used and the water is heated. This water may be changing or not. In this way flax has been retted in fifty or sixty hours. Retting, by whatever method, must be stopped at the right time or the fiber will be weakened and discolored. Certain chemicals added to the water hasten the process, but while they aid the destruction of the resins binding the fibers, they weaken the fiber and injure the color, thus detracting greatly from the value of the product.

Upon removal from the retting, the bundles of flax straw are set up in fields to dry, after which they are ready for the mechanical part of the separating process. The woody portion is now thoroughly rotten and may be crushed in the flax brake. The old brake consisted of a row of heavy slats, held firmly at each end. The straw was laid across these, and another set of slats, hinged to the first at one end and weighted at the other, was dropped down on the flax, breaking the woody tis-

sues. At the present time the same result is obtained by the use of fluted rollers run by machinery.

Scutching is the first rough process to remove the broken woody portion of the stalk. Originally a wooden block and a wooden knife were the crude implements used for this process. The flax was placed over the block and the knife struck off the woody part. A modification of this is the modern scutching machine, in which several wooden knives are mounted in a wheel and strike, as the wheel revolves, against a wooden block across which the flax is laid.

Hackling is a combing process and further frees the fiber from the woody particles. When done by hand the hackler holds a bundle of fibers in his hand and throws the free end over a set of upright teeth, drawing it carefully through. The short fibers, or tow, are separated out by this process, the long fibers, or line, remaining in the hackler's hand. Several sets of combs must be used, as the process must not only remove the tow, but must separate the flax into finer filaments and leave the line in untangled hanks. The tow remains in the comb and must be removed from time to time. It is used for coarse grades of yarn. The machine process differs only in the fact that metal needles, set in blocks of wood on a revolving apron, and wheels with teeth do the work of the hackler and his comb. Hand hackling usually supplements the machine work, especially for the better grades of flax.

Drawing and Spinning. Drawing, the next process, consists in pulling the hackled fibers out into a rope, which may then be drawn out finer and given a slight

twist, producing roving. Finally this roving is spun into yarn. Flax spinning is much more satisfactory if done in a moist atmosphere; in fact, the finer qualities can be spun only when wet. The hand spinner of former days kept a bowl of water at hand, in which she moistened her fingers as she spun. Yarn for warp

FIG. 31.—A. YARN WINDER B. FLAX HATCHEL
C. QUILLING WHEEL FOR FILLING SPOOLS

must be harder twisted than that for weft. The warp yarn is also given a light sizing to hold the thread together in weaving.

Weaving and Finishing. Weaving linen is rather more difficult than weaving cotton, because the fiber is not as elastic and when there is a sudden strain breaks instead of stretching as cotton does. For a long time fine damask was woven on hand looms, but these have

been almost entirely replaced by power looms. Some of the coarser linens, such as Russian crashes and other imported linens, are woven on hand looms by peasants in different countries. Linen bleaching will be more fully described later. If it be done most carefully it requires a combination of many washings, treatments with bleaching powder, rinsings, grass bleachings—processes requiring not only weeks of time, but proper fields upon which the cloth may be spread and favorable weather to do the grassing.

Finishing linen cloth increases the luster, adds sizing, and sometimes produces flat threads. Heavy pressing, calendering, and mangling after the addition of sizing materials give a good finish to the cloth and make it possible to handle the linen in the store without destroying its finished appearance. Beetling is a process of putting the cloth through a machine which beats the threads flat. Heavy clubs fall upon the surface of the cloth, making it closer in weave, increasing the luster, and giving the leathery feel so characteristic of good damask.

Sizing, when added in excess, makes a poor grade of cloth look well, and adds weight to any cloth. This may also make the material stiff, but after washing, this heavily sized material often disappoints the buyer.

Brown finishing is finishing the cloth without bleaching, and many of the most attractive linens on the market are those which are left in the natural colors of tan, brown, or gray. These unbleached linens usually wear better than the bleached, because the fiber has not been weakened by the chemical action of bleaching agents.

Proper methods detract little from the strength of the fiber, but in modern processes the wearing quality of the material is frequently not considered so much as the rapidity and cheapness with which the bleaching may be done.

Linen Fabrics. The difficulty with which linen is dyed limits somewhat the variety of materials which are made from it; yet there are many different effects produced by varying the weave, the size of yarn, the texture, and the degree of bleaching. Half-bleached, three-fourths bleached, and full-bleached cloth of different qualities may be purchased. Linens, from the finest, most delicate lawns to the coarsest crashes, are attractive for many purposes. Its rapid absorption of water makes linen the best material for towels, and its hard, smooth, lustrous surface leaves it unsurpassed for table use, while the fact that it is a splendid conductor of heat makes it a cool garment for summer wear.

The character of linen makes it wrinkle easily in dress material, but that same character causes it to lie smoothly on a table. Because of its resistance to coloring matter it does not stain easily, and the long fibers present few ends in the thread to become fuzzy like cotton. For these various reasons linen is a much valued fiber and commands a high price.

That this high price is legitimate may readily be understood if one considers the great amount of hand work necessary in the different stages of flax production. The culture, harvesting, rippling, retting, and bleaching all require hand labor, while in the preparation for spinning, and in the spinning itself, much less change

has been wrought by modern invention than in the manufacture of any other yarn. The price of hand labor in this country is almost prohibitive to the linen industry, and the climate is not well suited to grass bleaching. The high duty imposed by our tariff on imported linens keeps up the price.

The recent efforts to separate the fiber from some of the thousands of tons of broken flax straw, left after the threshing which separates the flax seeds, is a worthy measure for conservation. As has been said before, for the best quality of linen the flax must be pulled before the seeds are ripe; consequently the fiber from the crop grown for seed must be inferior to that grown for fiber. Again, the machine-threshing process leaves the stalks much broken, and the fiber obtained from it is short. Finally, the chemical retting process used will probably make the fiber weaker, so that the finest grades of linen will not be produced by this method. Up to the present time these manufacturers have produced only medium grade towels, underwear, surgeon's lint, etc. The writer has used some very fair towels made in this way.

Union goods of linen and cotton are excellent for some purposes; a linen and cotton towel is, no doubt, better than one of cotton alone, but not so desirable as a pure linen towel. It is doubtful if a mixed linen and cotton tablecloth is any better than a pure cotton one. Mercerized cotton is sometimes sold for linen, but, while a very good material in itself, it has not the characteristics which make linen so valuable. Excessive amounts of starch may give a firm appearance to poor linen.

Linen may be considered with silk a fiber of luxury, although to the housewife it seems indispensable for certain uses.

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CHAPTER VIII

BLEACHING AND DYEING

WITHIN the last sixty years the processes of bleaching and dyeing have changed from rule of thumb methods, handed down from generation to generation, and carried on most successfully by those who inherited the skill from their forefathers, to a most scientific method, requiring for best results the skill of the textile chemist. The workman who mixes the dyes and watches the machine is not necessarily as intelligent as the Oriental dyer in his native mountains, but the dyestuffs are not gathered from nature by the man who mixes them, and he is not even intrusted with the matching of shades.

The processes of bleaching and dyeing differ for the different textile fibers. The vegetable fibers have similar chemical reactions, and the animal fibers are somewhat alike in their chemical characteristics, yet each fiber must be treated in the way best suited to its individual needs. So many and such complicated reactions are involved in these processes that only a general statement of methods and principles will be given here. Since the chemical and physical structure and characteristics determine the treatment of the fibers in bleaching and dyeing, these may be briefly reviewed.

Cotton and Linen. Cotton consists of cellulose 87 per cent, water 8 per cent, and the remaining 5 per cent

vegetable wax, oil, albuminous matter, pectic acid, and coloring matter. The object of bleaching cotton is to remove this 5 per cent impurity, so that the fiber may be white or that it may absorb dyes readily; the oil and wax prevent this ready absorption.

Cotton is a single cell, hollow in the center, a collapsed tube.

Linen is not so largely pure cellulose, having about 15 to 30 per cent of foreign substance, besides 6 to 8 per cent water. The foreign matter is mostly pectic in nature and is difficult to remove. The linen fiber also differs in being composed of many cells held together by a gummy substance which may be dissolved by chemicals, making it more easily disintegrated than cotton.

In general, the treatment of cotton and linen in dyeing and bleaching is the same. Acids weaken or destroy the fibers, while alkalies, except in special cases, have little effect on them. Mercerized cotton has a greater affinity for dyestuff than ordinary cotton, and linen is more difficult to dye than cotton. Cellulose has very weak acid and basic properties, so weak that it does not combine directly with most dyes. Cotton has a very slight affinity for metallic salts.

Wool and Silk. Wool, being an animal fiber, is a nitrogenous compound. Much foreign matter is present in raw wool; in some cases less than 30 per cent of the weight of wool is fiber, 14 per cent is water, and the rest impurity. Most of this foreign matter is, however, removed before the fiber reaches the bleaching process.

Raw silk is composed of two substances. The fiber,

fibroin, is a nitrogenous compound; sericine, the gummy substance surrounding the fiber, is soluble in warm, soapy water and is removed in the cleaning process. About 73 per cent of silk is fibroin, 25 per cent sericine, and 12 per cent water.

The chemical actions of wool and silk are practically opposite to those of cotton and linen. Wool disintegrates readily in warm, rather dilute alkali; silk is not so readily affected. Acids, even when fairly concentrated, have very little effect on wool, but injure silk more readily. Both wool and silk have great affinity for metallic salts. The action of wool towards bleaching powder in cold and dilute solutions is one of chemical combination; the product, "chlored" or "chlorinated," wool, has a high luster, loses its felting property, and has an increased affinity for dyes. The absorption of metallic salts by silk gives the process of weighting already mentioned.

Wool sometimes acts as an acid, sometimes as a base, therefore combines readily with different classes of dyestuffs.

Fibers are made weak, or tendered, by certain chemicals. In the case of vegetable fibers, dilute acids and strong alkalies in the presence of air have this effect. Animal fibers are weakened by caustic alkalies, alkaline carbonates in boiling solutions, and concentrated mineral acids.

Absorption of Dyes. Owing to its physical structure, the single cell of cotton, with its central canal, doubtless absorbs dyes by capillary action. This, however, is probably largely due to pores which run from

the surface inward. Mercerized cotton, in which the central canal has almost entirely disappeared, has a greater affinity for dyes than ordinary cotton. Linen in the unbleached state has the cells of the fibers surrounded by a pectic substance that retains its natural coloring matter and resists dyes, and this is true to a certain extent of bleached linen.

The structureless silk fiber readily absorbs dyestuffs. So great is the affinity of this fiber for some classes of dyes that it is necessary to add the dyestuffs in several small amounts to prevent uneven absorption. The central or cortical layer of cells of the wool fiber takes up the dyestuff, while the outer, scaly layer does not dye so readily. This explains the depth of color obtained when looking into a pile material, where the cross section of the thread appears darker than the surface.

Operations Preliminary to Dyeing. When the fibers come into the hands of the dyer, either in the form of raw fiber, yarn, or cloth, they are in a more or less impure condition; besides the natural impurities there are present oil and dirt from the machinery and sizing in the cloth.

If the fiber is to be put upon the market pure white the process of bleaching is about the same as that for cloth to be dyed light colors; therefore only one process will be described here.

Three general operations must be gone through in this process:

1. The material must be thoroughly wet, so that every portion will be uniformly penetrated by mordant or dye, and not be protected from contact with it by bubbles of air, etc.

2. All impurities, such as vegetable or animal oils, which would prevent the fiber from taking up the mordant or dye, must be thoroughly removed.

3. The natural coloring matters, when they would interfere with the brilliancy of color to be produced, must be removed.

Cotton Bleaching. The process for cotton, bleached more commonly in the yarn or cloth state, consists of the following operations:

1. Boiling out. A scouring operation to remove all waxy and resinous matters in fiber.[1]

2. Treatment with bleaching powder solution to destroy natural coloring matter, and also to break down various non-cellulosic matters associated with the cellulose of the cotton.

3. Treatment with a dilute solution of acid called "souring," to dissolve lime compounds left in fiber from bleaching powder and to decompose any chlorine compounds which may have been formed.

4. Washing. For the purpose of removing all soluble matters resulting from the action of the bleaching powder and acid; also for the removal of the acid from the fiber.

5. Soaping and tinting, for cloth to be left white, neutralizes the last trace of acid, softens the cotton, and gives a slightly bluish tone to the white.

Various methods are used for carrying out these processes, and also different chemicals.

Lime preceded by resin soap was formerly used for

[1] Matthews. Laboratory Manual of Dyeing and Textile Chemistry, p. 45.

boiling out. In the madder bleach seven operations, viz.: 1, wetting; 2, boiling with lime water; 3, rinsing; 4, treating with acid; 5, rinsing; 6, boiling with soap and alkali; 7, rinsing, were carried out before treatment with bleaching powder; then followed the treatment with acid and the final rinsing.

Caustic soda is now commonly used for boiling out.

Bleaching powder, or chloride of lime, has the chemical formula $CaOCl_2$. It is a yellowish-white powder, partly soluble, used in a cold bath. Care must be taken that no undissolved particles are allowed in the bath, and that the cloth is entirely immersed, as the combined action of bleaching powder and air weakens the material.

Souring is usually done in a cold bath of very weak sulphuric acid, so that the cotton may not be made tender. Hydrochloric acid seems for several reasons to be better suited than sulphuric acid.

Soaping and tinting are done with dilute lukewarm solution of soap and a small quantity of blue dyestuff, as Prussian blue.

Recently hydrogen peroxide has come into use as a cotton bleach. Although expensive, it does not weaken the fiber and is used for some high grade cottons.

Linen Bleaching may be done in the same general manner as cotton, but the fiber is much weakened by the process. The pectic acid, or gum which glues the cells of the fiber together, is partially dissolved.

The old method of bleaching linen included bleaching both in the yarn and in the cloth. Mrs. Alice Morse Earle, in "Home Life in Colonial Days," says some forty processes of wetting, washing, bleaching with acids,

rinsing, soaking, bleaching on the grass, etc., were gone through with before the linen was pure white. These processes required many weeks.

The modern linen bleach is usually as follows for half bleach: first, the linen is boiled in sodium carbonate or in soda ash; then treated with bleaching powder, then with dilute sulphuric acid. After each of these operations it is thoroughly washed and the processes repeated; then if three-fourths bleach is required the cloth is spread on the grass and the sun and air do their work. For a full bleach, or pure white, the processes are repeated two or three times.

Linen loses from 25 to 30 per cent in bleaching, and becomes weaker as it becomes whiter. This weakening is more marked with chemical bleaching than with the old grass bleach methods, and this accounts in part for the great difference in wearing quality between the old homespuns and the modern machine-made linens.

Wool Bleaching. The operations preparatory to bleaching wool really begin when it first comes to the mill with the wool scouring, for here it is that the large per cent of dirt, perspiration, and oil is removed from the fiber. Later, when the yarn or the cloth is to be bleached, it is again washed in soap solution, and stretched to prevent tangling. Final bleaching is accomplished by hanging it, thoroughly moist, in brick chambers, into which the fumes of burning sulphur or sulphurous acid are brought. This operation requires from ten to twenty hours. The sulphuric acid formed must be thoroughly washed out of the wool when the bleaching process is completed.

Peroxides are becoming widely used as bleaching agents for wool. Hydrogen peroxide has been used, but the expense is almost prohibitive. Sodium peroxide is much less expensive, but must be handled with care, as when moist it is quite explosive.

Silk Bleaching. Silk bleaching differs somewhat from that of wool in that a large part of the coloring matter is present in the soluble gum which constitutes about 30 per cent of the fiber.

This gum may be entirely removed, as in boiled-off silk, where the material is boiled for an hour in a 25 to 35 per cent soap solution, rinsed, then boiled again from one-half hour to three hours in a 10 to 15 per cent soda solution. Souple silk has about one-sixth of the gum removed, and in this case the first soap solution has a strength of only about 3 or 4 per cent and the second bath consists of a weak solution of soda crystals. In each of these classes of silks the boiling is followed by a bleaching process, in which either the sulphur bleach or the hydrogen peroxide bleach is used.

Another class of silk, called "ecru," has but one-twelfth of the gum removed by scouring, and has no bleaching process.

Smoothing by the use of a 4 per cent cream of tartar solution softens the silk after these processes.

Since the cost of silk is greater than the cost of wool, it is more consistent to use the peroxide bleaches for it than for wool.

Silk that has a rustle has been treated with a weak acid, usually acetic or tartaric, which gives it this prop-

erty known as scroop. The acid is not washed off, but is allowed to dry on the silk.

Dyeing. The object of the dyer is to produce on a given material any desired color, with a certain standard of fastness. The demand may be for fastness to light; it may be for fastness to washing or, better, for fastness to both light and washing. The manufacturer must also consider the cost of the dyestuffs and of the process necessary to set the dye on the fiber. Here is one great cause of our many fugitive colors, for too often the finished material must be cheap.

There are two distinct types of dyestuffs: the natural dyes and the artificial—the aniline, or coal-tar dyes; the first class as old as the hills, and the second comparatively new. The Tyrian purple so highly prized in ancient days and used as a sign of royalty was obtained a drop at a time from a shellfish found on the shores of Tyre. The Egyptians early used gorgeous colors, obtained from plant and mineral sources, dyeing being a well-developed art even then.

The Oriental peoples, most famous for their beautiful rugs, guard sacredly the secrets of their dyes, which have been handed down and improved by generation after generation, until they are surpassed in beauty by no others. The famous tapestries of the Middle Ages and of more modern times have been colored with these dyes taken directly from nature and brewed by the skilled dyester, while the simple materials woven by our grandmothers were dyed with bark of walnut, leaf of sumac, or root of indigo.

Aniline Dyes. All this has been changed as a re-

sult of the marvelous discovery made by the chemist, Perkin, in the year 1856. While experimenting in his laboratory with aniline from coal tar he found the dye substance mauveine. This discovery, followed by many others, in time completely revolutionized the dyeing industry. There are at present hundreds of dyestuffs made from coal-tar products, which produce an enormous variety of shades, hues, and pure colors. The manufacturers of these dyes employ constantly an army of chemists to discover new dyes and to perfect the method of using those already known.

Considerable has been written in criticism of aniline dyes, and much of this criticism is just. The chief difficulty is that these dyes are so much purer than the natural dyes that the resulting colors are crude and hard. Also, many of the colors are fugitive and fade to ugly tones. When properly used, however, beautiful and fast colors may be obtained with greater certainty and much more cheaply than with the vegetable dyes.

Vegetable Dyes are still used to a certain extent by craft workers and by those who dye on a small scale. For commercial purposes, however, with the exception of logwood and indigo, natural dyes have almost entirely disappeared, and these two are rapidly being replaced by chemically prepared dyes. Cochineal, the coloring matter extracted from the bodies of the female of a small bug which grows on cactus plants, is still used to color the red coat of the British soldier.

Primitive peoples still use the natural dyes. When they use yarns dyed with aniline dyes, as some of our Western Indians have done of late years, their products

are anything but artistic, since they do not know how to handle these colors.

It is a capital offence to carry aniline dyes into Persia; in this way the law has protected the beauty of the Persian rug.

Household Dyes. Aniline dyes especially prepared in small packages for vegetable or for animal fibers are known to the housekeeper. Those dyes are chosen which will produce the best results in unskilled hands, and are combined with the chemicals necessary to produce this result. The dyer needs to add only common salt or vinegar as an assistant.

Mordant. Certain dyestuffs produce a fast color on a fiber, while others require the action of some chemical to bind the dyestuff to the fiber. The chemical which is used to combine with and fix a dye upon a fiber is called a mordant. A dye which requires a mordant for one fiber may not require it for another. In general, vegetable fibers require mordants more often than do animal fibers.

The theories of dyeing are not entirely established yet, some authorities holding that there is a chemical reaction between the fiber and the dyestuff by which a compound called a lake is produced. Others hold that the process is merely a mechanical one, and that the color particles are deposited on the fiber. Both theories have evidence in their favor. A third theory is that the fiber is capable of dissolving the dyestuffs and producing a solid solution. Whichever theory is the true one, conditions of heat, amount of liquid, and elements in the dyebath greatly affect the result produced.

Use of Mordants. It has been said that a mordant is a chemical substance which combines with the dye to produce a fixed color on a fiber. Certain metallic salts have this power. They are absorbed by the fiber, and then mordant and dye combine to form an insoluble color lake. Vegetable fibers, however, do not have the power of absorbing these metallic salts to any great extent, but do combine with tannic acid. The tannic acid may then combine with a mordant, and finally the dyestuff is brought into combination. In some cases the mordant is applied to the fiber first, then the dye added, or the mordant and dye may both be put into the same bath. Common mordants are salts of aluminum, chromium, iron, and tin. In the old methods of dyeing, alum and chrome were common mordants. Tannic acid was obtained from gallnuts or sumac.

Assistants. Glauber salt, common salt, acids, or alkalies are used with different dyestuffs to hasten or delay the process or to regulate the distribution of the dyestuff, according to the properties of the dye or of the fiber.

After-Treatment. Certain colors are produced on fibers by after-treatment with various agents. The color may be merely a deeper tone of that originally produced by the dye, or it may be a different color. The object in producing colors in this manner is to gain fastness.

Classification. Dyes are usually classified into four groups, according to their general properties.[1]

"*a.* Acid dyes.

[1]Matthews. Laboratory Manual of Dyeing and Textile Chemistry, p. 58.

"*b*. Basic dyes.

"*c*. Substantive dyes.

"*d*. Mordant dyes.

"This classification in a general way is based on the chemical nature of the dyestuff and its reaction towards the fiber. The following is a brief summary of these properties:

"*a*. Acid dyes. Salts of color-acids; dye animal fibers directly; do not dye vegetable fibers; mostly applied to wool and silk.

"*b*. Basic dyes. Salts of color-bases; dye animal fibers directly; dye vegetable fibers on a tannin mordant; mostly applied to cotton and silk.

"*c*. Substantive dyes. Of neutral chemical nature; dye both animal and vegetable fibers directly; mostly applied to cotton and somewhat to both wool and silk.

"*d*. Mordant dyes. Of neutral chemical nature; dye neither animal nor vegetable fibers directly, but require a metallic mordant; mostly applied to wool."

Some other dyes not included in these groups are the mineral pigment dyes, as Prussian blue, vat dyes, such as indigo, and sulphur dyes.

Acid Dyes. The acid dyes are cheap, and are most commonly used for wool. The dye is dissolved in an acid bath, with considerable Glauber salt. The cloth is put in at a low temperature and the water gradually heated. With an alum mordant on cotton the acid dyes give colors fast to light but not to washing.

Basic Dyes are much used for silk, since this fiber has a great affinity for them, and the colors produced have much depth and brilliancy. An after-treatment with

tannic acid and tartar emetic increases the fastness to washing.

Basic colors are not used as much for wool as formerly, since acid dyes give better results. With cotton the cloth is first mordanted with tannic acid, then with salts of antimony or iron, and finally dyed.

Hard water may not be used with the basic dyes, as the color is precipitated and dye spots result.

Direct Cotton Colors, or substantive colors, may be used for either animal or vegetable fibers, and for this reason are largely used for union goods. Their worst fault is a lack of fastness to light and washing, a difficulty which may be lessened by an after-treatment of the material. This after-treatment usually consists in developing on the fiber by some chemical treatment an insoluble dyestuff from the more or less soluble dye already present.

Mordant Dyes are dyes which cannot be used on any fiber without a mordant. Madder, logwood, alizarin (Turkey red), are common examples of these dyes. Many of the old natural dyes belonged to this class. They are usually rather fast colors and are more difficult to dye.

Vat Dyes. Indigo is an interesting example of vat dyes. These dyes are in an insoluble form, and must be reduced to a soluble form before they can be applied to the material. Indigo as it comes to market is a blue powder or paste prepared from the root of the plant *Indigofera,* or prepared synthetically from coal-tar products. The two substances are chemically identical, but the synthetic product is purer than the natural one.

When indigo is reduced by action of copperas and quicklime or other agents, it yields a grayish-white product, indigo white, whose calcium salt is soluble in water. The cotton is impregnated with indigo white, then exposed to the air, when oxidation takes place producing the blue indigo again in insoluble form on the fiber.

Sulphur Dyes are those requiring sodium sulphide to produce a solution. They are especially fast to light and are used largely for linens and silks. They require after-treatment with potassium dichromate or by exposure to air.

These different classes of dyes include hundreds of different dyestuffs with many names. Firms such as Cassella, Metz, Badische, and others have their distinctive names for different dyestuffs. These and many other large firms are German, but have American agents.

The use of the different classes of dyestuffs requires considerable knowledge of chemistry and long practice in handling. The difficulties in securing even colors, fast colors, true shades, and always the same shades are many.

Precautions in Using Dyes. With certain classes of dyes hard water must not be used, as the calcium and magnesium in the water precipitate the dyestuff, while impurities like iron or organic matter may cause trouble. Careful solution of the dyestuff that it may be evenly distributed, regulation of the temperature of the solution, and the proper use of assistants are all important precautions.

Sometimes a material may be dyed with a dyestuff of one class, then topped, or dyed again in another kind

of dyestuff. Basic dyes may be used on cotton, on a tannin mordant, the cotton being then dipped in a direct cotton dye. The color acid of the direct cotton or substantive dye unites with the color base of the basic dye and forms an insoluble compound.

In dyeing cotton with basic dyes two mordants may be used. The cotton may be saturated with tannic acid solution, then with an antimony salt, a tin salt, or an iron salt, and finally dyed. An acid bath is used for cotton and a neutral bath for wool.

With so large a choice of dyestuffs and so many methods of using them, it will readily be seen that the handling of dyes, if the best results are to be produced, is no task for the amateur. Because of the greater cost involved in dyeing fast colors, the manufacturer is tempted to produce fugitive ones. Chemicals used to assist the dye process may weaken the fabric if they are allowed to act too long, or if they are not entirely removed from the cloth when the dyeing is complete.

Very crude, as well as the most refined, colors may be obtained from these dyestuffs. It remains with the dye expert to decide which. That aniline dyes may be used for the most artistic products has been proved in the Herter Studios in New York, where silks, wools, linens, and cottons for the most wonderful tapestries, rugs, and hangings are dyed in the chemical dye pot.

Oil Paints. A recent development in amateur dyeing is the use of oil paints and gasoline. The process is very simple. The desired color may be obtained with little difficulty by any one who understands the mixing of paints. Only a limited amount of material may be

successfully dyed in this way, but it is especially suitable for nets, laces, and other delicate materials.

The process consists in mixing the paints until the desired hue is obtained, then dissolving in gasoline. The fabric is dipped several times in the solution and dried.

Printing. Before the dawn of history man had learned how to decorate the surface of his fabrics with colors. The primitive South Sea Islander applies color to his bark cloth by dipping a fern leaf into his dye made from bark, berries, or colored earths, and laying the leaf

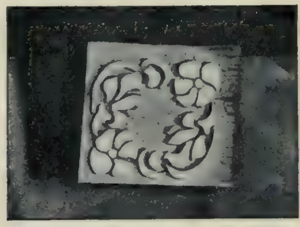

FIG. 32. — BLOCK FOR PRINTING

on the cloth. Higher up in the development of industries comes the use of a stencil, wonderfully developed by the Japanese. A block of wood with a design engraved upon it, which was dipped in the paint and then applied to the cloth, was an early method of printing. With the development of machinery came the copper roll with the design engraved upon it, this giving a continuous application of the pattern, whereas the block print must be applied separately for each repeat of the pattern. At the present time both the wooden block and the copper roll are used, although for general commercial purposes the block has almost disappeared.

The purpose of printing, as opposed to dyeing, is to produce upon the cloth a design in one or many colors without the complicated weave that would be necessary if it were produced with threads dyed in the yarn. The effect obtained is also very different from the effect of a woven design. In organdies and thin materials it would not be possible to produce the delicate color effects in any other way except by hand painting.

Printing may be done on woven cloth or on the warp threads before weaving. The latter method produces a somewhat indefinite or soft effect, very attractive in Persian silks, Dresden ribbons, and other materials. This method is used also in tapestry rugs, where economy of material is desired. In this case, however, the result is not particularly good.

The machinery used for printing consists of a large drum with an endless blanket, over which the cloth passes slowly, and copper rolls, one for each color in the design, revolving in close contact with the cylinder. The part of the pattern to be produced in any one color is engraved on its particular roll; therefore in very elaborate designs there may be as many as twenty rolls. The colors for printing are mixed, thickened with gum, and put into troughs just below the copper rolls. A feed roll covered with felt dips into the dye and comes against the copper roll, supplying it with color. A strip of steel called a "doctor" scrapes all the dye off the copper roll, except that which is in the engraved parts; this goes onto the cloth, and there must be just enough to print the pattern, but not enough to run. Since the large drum is heated the dye is almost immediately dried.

There are three methods of producing a printed design on a cloth. The first or direct method is given above, and is used mostly for cloth with a white background. For cloth which is to have a colored background with the figure printed upon it, other methods are used. In the discharge method the cloth is first dyed a solid color; the design is then printed on with some chemical which removes the color from the spot which is to furnish the design.

The resist method consists in printing the design on the cloth with a chemical which prevents the absorption of the dyestuff, and thus, when the cloth is dyed later, the design is left white or of the desired color. A great variety of effects may be produced with the discharge and resist methods of printing. The greatest difficulty with them is that frequently the chemical used is too strong and weakens the cloth, especially if it is not entirely removed. Sometimes in cheap prints the figure will drop out entirely, long before the main body of the cloth is worn out.

Careful mixing of color and thickening agent, of color and mordant, or proper mordanting of the cloth before printing is very essential. The color is usually developed after printing by steaming or by treating with a chemical developer. Care must be taken that the machinery is adjusted exactly; otherwise too little or too much color may be applied.

When printing warps, the threads must have been previously wound on the warp beam as they are to go into the loom, and this relative position must be kept.

The possibilities of machine printing are numerous,

and the results may be beautiful or hideous according to the taste of the designer and the choice of colors.

Block printing is still used by craft workers and in the manufacture of expensive chintz, cretonne, silks, etc., where the design is very elaborate and a particularly

FIG. 33.—COTTON PRINTS

A. Japanese Print B and C. French Chintz printed on warp before weaving

artistic effect is desired. Block printing has a more individual appearance than machine printing. The Japanese are past masters in the art of block printing, as they are in stenciling, their prints on paper being most wonderful.

Liberty & Company, London and Paris, produce beautiful block-printed silks, satins, and cottons at their

print works in Merton Abbey, England, where are also located the print works started by William Morris, in which blocks only are used.

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CHAPTER IX

ADULTERATIONS AND BUYING

IN the foregoing pages the effort has been made to show how modern machine methods, modern scientific knowledge, and modern competition have changed the character and increased the quantity of textile fabrics on the market. Frequently increase in quantity has meant decrease in quality, cheap production has meant poor material, and haste has meant waste. There is a great variety of excellent materials on the market, materials which compare well with hand-made productions in wearing quality and which excel in beauty of finish. There are also many materials poor in quality, although often attractive, which are the result of this new era of machinery. They are deceptive in appearance, are sold under misleading names, and are not worth the prices put upon them.

The transition from "home-spun" to "factory-made" has not only affected the fabrics on the market, but it has also changed the position of woman in the home. Woman is no longer the producer, but she is more than ever the consumer of textile fabrics. The removal of the textile industries from the home has brought woman out from the home into the factory, or it has given her time to go more into public and has greatly increased the occupation of shopping. The increase in ready-made clothing and household linens, by removing a large part

of the sewing from the household, has furthered this change.

In olden times the quality of home-spun and home-woven material was the best possible to be obtained from the materials by the methods then known. Woolen cloth was all wool and linen cloth was not half cotton or adulterated with starch. Honest and durable materials were the rule of the day. Modern discoveries, mechanical and chemical, have increased the possibilities of cotton, linen, silk, and wool, so that it is frequently difficult to recognize the material as it appears in the finished cloth.

On the one hand, the field of textile knowledge has grown enormously; on the other hand, women, although becoming more and more the buyers of fabrics, have less knowledge of the quality of materials, because they do not gain that knowledge through the making of cloth, often not even through the making of garments. The result has been that they depend more and more on the word of clerks who are often as ignorant as themselves, until by painful experience they learn some of the things to be avoided.

As the cost of living increases it is likewise important that the woman of the household should know how to spend the family income most economically. Since from ten to twenty per cent of this income is spent on clothing and house furnishing, it is imperative that more thought and careful study should be given to this branch of household economy.

The problem of buying is more complex than many people realize. It is only quite recently that thoughtful

women have considered the far-reaching influence which their selection may have upon others. The laws of demand and supply hold for the household buyer just as they do in larger transactions. Every woman, as she buys her day's food supply or her fall gown, does just so much toward setting the standards for the grocer, the garment maker, or the factory worker. The buyer may take her place among the thousands who know not and care not how the other half lives, or she may join the smaller army of those who demand some information about the conditions under which their garments and food are made, and who are slowly making sentiment for better conditions. The protection of the home against foul diseases, as well as the protection of the health of the worker, requires that certain existing conditions shall be done away with. Increasing emphasis is now laid upon the hygiene of clothing; the buyer must consider if the material she chooses can be kept hygienically clean, if it answers the body requirements of removing perspiration, and of protection from heat or cold. The conditions under which materials are manufactured, the hygiene of materials, and color and design will be more fully discussed in later chapters.

Increase in culture demands more artistic clothing and house-furnishing material. The artificiality of modern civilization has increased the number of household furnishings and of clothes, and has replaced the simplicity of an earlier period with a great variety of shades and lines and with numberless designs. The buyer has great opportunity to exercise good or bad taste in choosing materials from such an array.

The economic side of buying should receive the careful study of every woman. How best shall the available money be spent in order that the greatest return in quality and quantity may be secured? Fashion, that lord over all dress, and too often over house furnishings as well, is responsible for an enormous amount of waste. Clothes are not expected to wear any length of time; it is not desirable that they should last more than one or two seasons. The manufacturer does not try to make his colors fast and his materials long-lived, for that is not what the public demands. Variety and novelty are the cries of the day, and in order that these may be supplied cheapness must often go along with them. The woman who does not care for novelty and variety, but is willing to pay a reasonable price for her materials, finds herself confronted with a problem, because she cannot distinguish durable cloth and because the market does not always afford the long-lived materials, at least for those of limited income.

The label attached to a material and the word of the clerk are not always reliable; the price is not necessarily an indication of quality; even an intimate knowledge of materials sometimes fails to detect a hidden weakness. Chemical tests are not available in every household, and cannot be applied to the ready-made garments. A high power microscope distinguishes one fiber from another, but, again, the microscope is within reach only of the few. Until the law requires the labeling of textiles as it requires the labeling of food, knowledge of the character of materials and of the methods used by the manufacturer for the adulteration of these materials,

together with eternal vigilance, must be the protection of the buyer. In the study of the individual fibers certain characteristics were mentioned which aid the manufacturer in increasing the luster or the weight of different materials—instances of imitation silks, of made-over wools, of the use of one fiber to adulterate another. It may be well in this chapter to review these devices for increasing the apparent value of materials. Each fiber will be considered separately and then a summary given.

COTTON

Cotton we have found to be cheap and plentiful, and the demand for cotton cloth may easily be met with good material. It is manufactured into a great variety of fabrics, and is capable of replacing to a certain extent any other fiber. The quality of cotton cloth depends on the strength of the fibers, the fineness or coarseness of material, the weave, the color and design, and the adulterations. The kind of cloth to be bought depends on the use to which it is to be put; the quality demanded depends on the use and also quite largely on the price to be paid for the material.

The adulterations of cotton cloth are not numerous and are not difficult to distinguish. Being the cheapest of fibers, it is not adulterated with any other fiber, but it may be increased in weight and apparent firmness by the addition of sizing. This sizing, of course, does not increase the wearing quality of the cloth, and may have the opposite effect of weakening it considerably by the presence of injurious chemicals. If these are present in large quantities, the cloth loses greatly in weight and

firmness with the first washing. A certain amount of sizing is necessary to give the cloth a good finish and to enable it to keep its shape while being handled upon the counter, but this amount is frequently very much exceeded. Adulteration of this kind may be detected by the feeling, as a large quantity imparts harshness to the material. In very thin fabrics the sizing may often be detected by holding the cloth up to the light, to show the starch between the threads. Washing or boiling a sample thoroughly will show the amount of sizing present.

Another method used to adulterate cotton with sizing or pastes is the imitation of an embroidered Swiss or other thin material. In this case the design is printed on the cloth in heavy paste, instead of being embroidered in. This device gives most unsatisfactory results when laundered. The dots either disappear in washing or turn brown when ironed even at a temperature considerably below that necessary to burn the cloth. The imitation of mercerized cotton by heavy pressing with engraved rollers has been mentioned. The luster thus obtained is frequently on only one side of the cloth, and has a different character from that of true mercerization. If the sample is washed, the imitation luster disappears, while true mercerized luster is permanent.

It is well to test the strength of cotton goods by tearing slightly at the edge of the material. It may have been weakened by the bleaching process, or a bolt which has been some time in stock may have become considerably weakened by the action of the chemicals in the sizing or the dye.

Standard cotton materials, such as muslin, organdie,

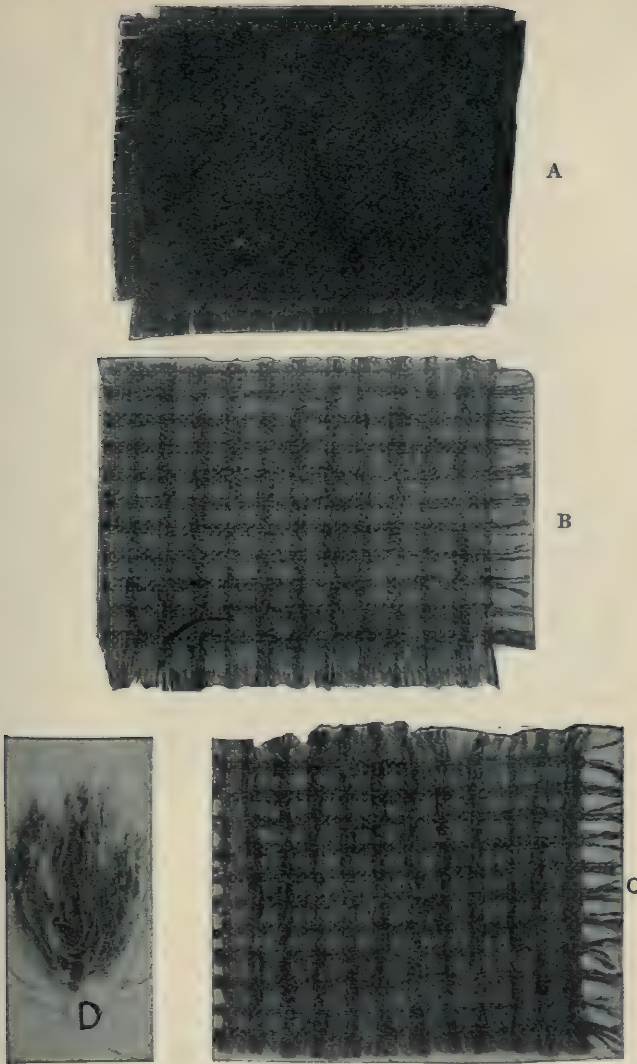

FIG. 36.—A. ALL-WOOL WORSTED, \$0.75 A YARD B. SAME PRICE, CALLED WOOL C. COTTON LEFT FROM B WHEN WOOL REMOVED BY CAUSTIC POTASH D. WOOL LEFT, COTTON REMOVED BY ACID

percale, calico, and sheeting, differ only in weight of material, fineness of thread, hardness of twist, or method of finish. Ginghams have the thread dyed before weaving and have fancy weaves, with the introduction of silk threads in some grades. Duck, denim, and other heavy materials have very hard-twisted threads, and are frequently woven with a twill. Silkolene is a trade name for a fine cotton cloth with a silky finish given after the cloth is woven. Madras, shirting, cheviot, chambray, and many other names are applied to materials with fancy weaves, figures, or stripes. Chintz and cretonne are names given to heavier print goods used for house furnishing. Mercerized cotton makes a number of attractive lustrous materials for dress and for furnishing. Among these may be mentioned poplin, imitation pongee, and "Egyptian tapestry," the last being used for hangings.

India "linon" is entirely cotton; "Canton flannel" has a fleecy surface on the wrong side, and "outing flannel" is fleecy on both sides, but both are cotton.

Many "tussahs," "voiles," "economy linens," and other materials with rather deceptive names are cotton made to imitate silk, wool, or linen.

WOOL

The adulterations of wool are more serious than those of cotton. The excellent qualities of wool, its warmth, its ability to keep its shape and smoothness through long wearing, the richness of material made from it, the ease with which it absorbs and retains dyes, all contribute to create the immense demand for woolen cloth. At the present time this demand so far exceeds the supply that

one-third of the woolen cloth on the market is made from old rags worked back into fiber and respun. This made-over wool, or shoddy, appears in various forms. It may be quite good in quality and be woven into woolen cloth without the addition of new wool. A small quan-

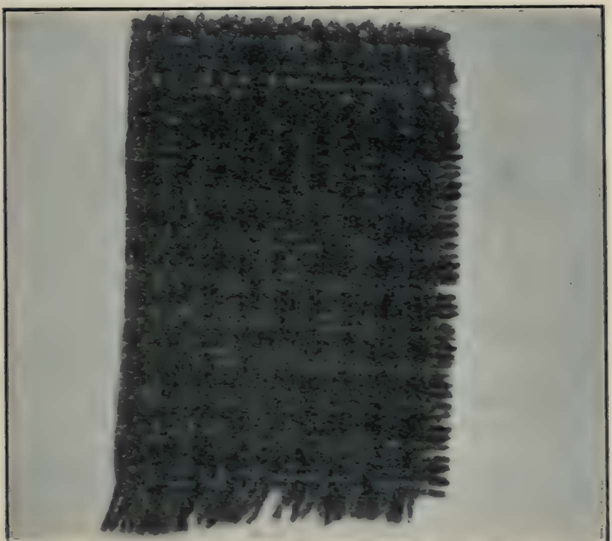

FIG. 35.—CLOTH MADE FROM SHODDY AND COTTON

tity of new wool or of cotton may be mixed with shoddy, when a better wearing material will be the result. Short fibers, either shoddy or the clippings from tailors' shops, sweepings from looms, etc., may be matted into the surface of cloth to add weight and thickness. This treatment may often be detected by raveling threads from the cloth, when the very short fibers drop out. Shoddy

supplies a cheap wool, with good warmth, but does not look as rich as a more expensive cloth or wear as long as new wool. The threads from a piece of shoddy break easily, and when raveled the short fibers are exposed. Under the microscope broken and imperfect fibers may be detected, as well as unevenness in size of thread and in color.

The use of cotton to adulterate wool is very common, and because of the felting property of wool much cotton may be concealed in a woolen cloth. In worsted cotton is more easy to detect, as it may not be carded with the wool, but a spun thread of cotton can be mixed with a spun thread of wool. Burning serves to distinguish cotton from wool, although this is not an exact test. Cotton burns much more quickly than wool and with more flame; wool has an odor of burnt feathers, chars, and leaves a crisp ash. The broken end of a wool thread shows fibers stiffer and more kinky than the broken end of a cotton thread. Here the microscopic test is most satisfactory.

In some materials the mixture of cotton and wool is a good one. Especially is this true in undergarments, when the cotton comes next to the body, absorbs the moisture quickly, and gives it up gradually to the wool outside. The manufacturer, however, is not always willing to say that his undergarments contain cotton. "Wool" union suits have been found with varying amounts of cotton, from about ten per cent to perhaps ninety per cent, and some "all-wool" garments are really all wool. In dress material the greatest objection to the mixture of wool and cotton is the uneven shrinkage of

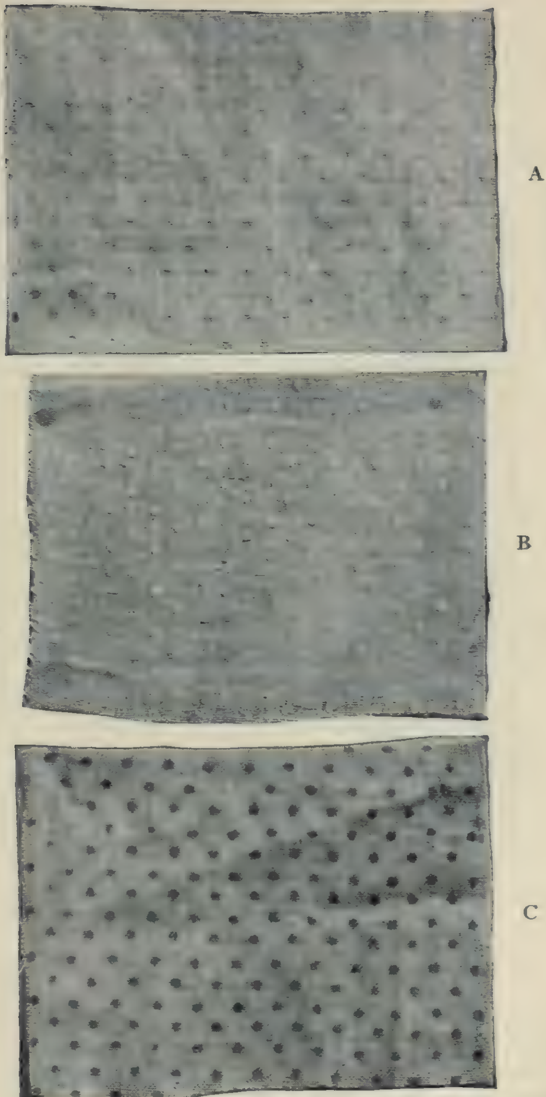

Fig. 34.—A. Imitation Dotted Swiss, Paste Dots Printed On
B. Same after Washing a Few Times
C. Pressed with Hot Iron

the two, which makes it impossible to keep the material well pressed. There are exceptions to this in mohair and alpaca, where the wool is much more hair-like and does not shrink and felt as sheep's wool does. In this

FIG. 37.—MOHAIR, SHOWING COTTON WARP; WOOL REMOVED BY CAUSTIC POTASH

case the cotton is not considered an adulteration, as the material is not sold for all-wool and does not command a high price. Poor grades of wool are disappointing in that they soon wear shabby, shrink badly when wet because of lack of proper shrinkage in making, and lack fastness of color.

There are many grades of woolen and worsted cloth, varying in weight, firmness of weave, finish, purity, color, weave design, etc. The standard broadcloths, worsted suitings, expensive voiles, etc., materials which bring a good price, are usually all wool and wear well. Here again the "novelty," the new material for the season, not always the lower-priced cloth, though frequently so, is the one to be examined. Unfortunately, the poor-grade cloth usually sells at the price which catches the buyer who can least afford to be deceived and to whom economic waste is most serious.

SILK

Since silk is the most expensive fiber and has characteristics which make it very easy to adulterate, the manufacturer frequently yields to the temptation offered him. The best grade of silk, that reeled from the cocoon in one continuous thread, possesses a high luster, beauty, and strength not to be duplicated. Silk carded and spun from inferior cocoons lacks the luster and strength of reeled silk, but may be used in combination with it to produce excellent materials. This inferior silk is frequently used for the back of velvet and satin and for the warp of silk woven with the sateen weave, when the luster is produced by the filling thread. The thread of spun silk is quite like cotton. It has short fibers whose ends appear fuzzy on the surface of the thread. Poorer qualities of silk, imitation pongee, and some thin, cheap silks are woven entirely of spun silk.

Two generations ago the quality of silk cloth was much superior to that now found upon the market, but

the price was also much higher. The public has demanded silk for common use at a low price, and the manufacturer has met this demand by using less silk in a given material and making up the weight by increased amounts of dye, metallic salts, gum, etc., which the silk fiber readily absorbs. This loading process reduces the wearing quality of the fiber and often causes it to split or to wear shiny. Practically no silk can be found entirely free from loading, but the amount differs greatly in different materials. It is considered legitimate to add thirty per cent, the equivalent of the loss due to the removal of silk gum in the boiling-off processes. Taffeta is commonly heavily loaded, while China silks and other thin silks, as crêpe de Chine and chiffons, which weigh only a few ounces per yard, are comparatively pure. Softness and luster do not serve to distinguish pure silk, as a lustrous finish may be given to a heavily loaded silk.

The simplest test for weighting consists in burning a thread or a piece of the fabric. Pure silk burns slowly, leaving as it burns a small amount of ash in the form of a crisp ball at the end of the thread or a crisp edge when the fabric is burned. Heavily weighted silk burns leaving the ash in the form of the original thread or cloth; this ash, of course, drops to pieces readily.

The cost of raw silk is about thirty times that of raw cotton, and the loss of silk at least five times that of cotton. The prices charged for silk fabrics are not at all equivalent to this difference. Silk is frequently woven with cotton, but it is not possible to spin a thread of the two together. In satins, velvets, and brocades the

cotton forms the back of the cloth, and is entirely covered by the silk threads on the surface. In cheap silks a fine cotton thread sometimes forms either warp or filling. Mercerized cotton and spun silk are woven together to form a material which resembles pongee, and is sold under the names of rajah and tussah, or similar materials may be made entirely of mercerized cotton.

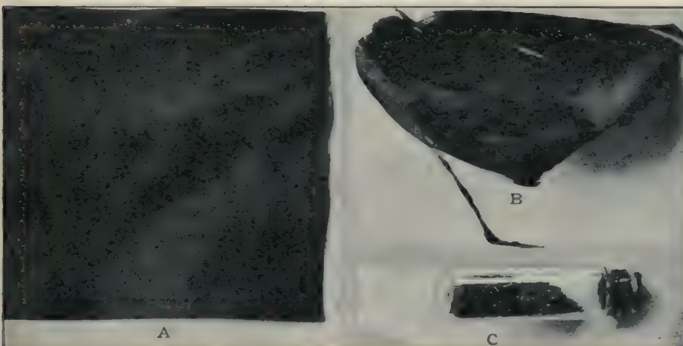

Fig. 38.—A. Sample of Silk B. Same Burned in Flame C. Ash after Thorough Combustion

Gave test for tin, aluminum, chromium, and iron; this with glucose gums, etc., made up 60 per cent of sample

Such materials may be excellent in themselves and may wear well, but they should not be sold as good silks.

Artificial silk is now produced in large quantities, and is found in braids and passementeries. When tested chemically it acts as a vegetable fiber. It is weakened by the continued action of water.

The variety of silks on the market is very great, and the problem in buying them is a difficult one. To a certain extent cost is a protection, yet expensive silk

may be poor. Heavy silks at a low price are a dangerous investment. The mark of the manufacturer in the selvage of silk is a good sign, as a manufacturer does not often flaunt his label upon a poor material.

LINEN

Because of the high value put on linen, it is, like silk, often adulterated. Although similar to cotton in chemical structure, it is very different in physical characteristics, and these physical characteristics must serve to distinguish it from cotton. In many cases cotton has replaced linen in modern usage, but for table service, towels, and handkerchiefs linen is much superior; for sheets it is preferred by many, and for clothing it is handsomer. For all of these uses cotton may be found mixed with linen, or with no linen at all, yet sometimes stamped and sold as linen. "Linen" collars are rarely all linen, frequently all cotton; "linen" handkerchiefs, especially inexpensive embroidered ones, are often entirely cotton, and table "linen" may be linen, linen and cotton, mercerized cotton, or ordinary cotton.

The combination of linen and cotton may be good for certain purposes, but when beauty of a lustrous surface, snowy whiteness, or the peculiar leathery texture which enables linen to hold its place so well on a table are desired, the mixture of cotton is very detrimental. For absorption of water in towels and handkerchiefs cotton is not as good as linen.

To distinguish the two nothing is so sure as the microscopic test. The long, straight fiber of linen is

readily distinguished from the twisted fiber of cotton. The linen thread is stronger than cotton, has more luster, and is usually less even. The ends of the short fibers of cotton project from the surface of the thread, giving a rough appearance, especially when the thread is rubbed between the fingers; when broken, cotton has a tufted end, while linen breaks more unevenly and leaves a long, pointed end. Some kinds of linen have flat threads, but cotton is frequently finished in imitation of flat thread linen.

The old test of moistening the finger and putting it under the cloth is not always a sure one, as the moisture will not come through a heavy linen or one with much starch in it, and will come through a sheer, tightly twisted cotton. A better test is to put a drop of olive oil or glycerin on the cloth and press it between blotting papers. If there is not much starch present, or if the starch has first been removed from the cloth, linen becomes more transparent than cotton.

The typical weaves used for linens are as follows: the damask, satin, or sateen weave used for table linens and towels is especially good for the former, because of the smooth, lustrous surface it affords, but is not so good for towels, since it does not absorb moisture readily, although it is very attractive; huck, an uneven weave, gives a good surface for the absorption of water, makes excellent towels, and when decorated with designs in damask weave may be very handsome. Many linens in plain weaves are available for clothing and embroidery. Sometimes the threads are round, sometimes beaten flat.

The texture of linen is such that the heavier kinds

hang well in folds, lie flat on the table, and are very artistic for many purposes. This beauty of texture is lost when starch is added.

Large quantities of starch or sizing are added to thin, poor quality linens to give an attractive appearance. These are disappointing when the filling is removed by washing. Careful examination when buying will detect this starch. It is necessary to add some starch in finishing most linens, so that they will not become too badly soiled with the handling received on the counter. This starching should be distinguished from excessive weighting.

Certain coarse, heavy linen crashes, often hand-woven peasant products, have become popular of late for house furnishing purposes. The heavy thread and uneven weave give a pleasing texture, and the natural color of the linen is attractive; the fabrics lend themselves especially well to coarse embroidery, stencil, or appliqué.

Summary

To sum up, the adulterations most likely to be found and the simple tests for them are as follows:

1. By combination. Use of other fibers than the one indicated by the name of the material. Example, cotton in woolens, cotton in linens, etc.

2. By substitution. Selling one fiber under the name of an entirely different one. Example, mercerized cotton sold for silk or linen.

3. By increasing the weight of a material. (*a*) Cottons and linens with starch; (*b*) silks with metallic salts and dyes.

4. By giving a finish which is deceptive. (*a*) Heavy pressing or calendering on ordinary cotton to imitate mercerizing; (*b*) finishing cotton to look like linen; (*c*) printing paste dots on cotton to produce the effect of embroidered dotted Swiss.

5. By use of made-over yarns. Example, shoddy in woolens; also addition of short wool, felted in surface.

Tests for Adulteration

1. Examination of cloth to see if all threads are alike and to distinguish kind of thread.

2. Examination of individual threads.

Cotton: short fibers; ends appear fuzzy in thread.

Wool: short fibers; decidedly kinky and stiff.

Silk: long, straight fibers with luster; if spun silk, fibers short; thread looks more like cotton; breaks more easily than reeled silk.

Linen: strong threads; high luster; when broken, ends very uneven and straight.

3. Burning tests: (*a*) Cotton burns quickly with flame; (*b*) wool burns slowly, chars, gives off odor of burnt feathers; (*c*) silk burns slowly, leaves small, crisp ash, and when weighted leaves more ash; (*d*) linen, similar to cotton.

4. Linen, if without much starch, becomes translucent when treated with olive oil; cotton remains opaque.

5. A mixture of cotton and wool when wet wrinkles more than pure wool.

6. A careful examination of the finish of the material. Observe, if alike on both sides, if the apparent beauty of the material is due to finish or to good quality of material.

An intelligent understanding of what one must look for, and continued practice, in time greatly increase the ability to buy intelligently. Laboratory work in the identification of fibers and the analysis of materials gives a more thorough familiarity with fabrics. Some of these tests might easily be applied in the household.

A demand on the part of buyers for better materials might help in securing honest fabrics. Better still would be a pure textile law to protect from adulterated textiles, as the pure food law seeks to protect from adulterated foods. According to the statements of the textile interests such a law would be impossible, but at least it would be interesting to see it attempted.

CHAPTER X

THE HYGIENE OF CLOTHING MATERIALS

WITH the great movement throughout the country for public health, there seems little excuse for ignorance regarding fabrics that conserve health, yet the general public is ignorant or indifferent, or both, to organized effort for better conditions. Much has been said about the athletic American woman and her sensible clothes, but she is still woefully lacking from the strictly hygienic standpoint. Education, common sense, and combined effort need to be applied to the clothing problem, not to produce a sudden or peculiar dress reform, but to improve still further dress of the present day.

Machinery produces an endless variety of materials, artists create beautiful costumes, the gymnasium, the tennis court, the swimming pool develop splendid figures. Yet colds, pneumonia, and tuberculosis are too prevalent. Undoubtedly improper clothing must bear part of the blame for this.

From the arctic regions to the heart of the tropics men wear clothing of one kind or another. Sometimes this clothing is very limited, but even the string of beads of the Central African serves his purpose of dress. The clothing of the Eskimo prevents him from freezing to death; the South Sea Islander satisfies his love of dec-

oration with the few garments he wears, and charms the tropical lady with his belt of feathers.

Throughout history dress has fulfilled one need or another. In modern civilized society it must satisfy several demands. Protection from the elements, modesty, ornament, and fashion must all have a place, and it is often difficult to provide for all of these needs in one costume. The special field of hygiene of dress is the proper protection of the body, not only from the elements, but also from the tyranny of fashion.

It is not the purpose in this chapter to discuss the large problem of proper clothing, but merely that part of it which has to do with the qualities of materials. To understand this question one must know what bodily needs clothing has to fulfill and what qualities different materials have to enable them to meet the requirements. Living conditions have changed greatly in the last few decades. Houses are warmer, street and railway cars are overheated, public buildings are often hot, and the home is not as draughty as it used to be, therefore the costume which was proper two generations ago is not suitable today. There are still, however, cold days and damp days, and outdoor conditions are much as they always have been. Modern physiological science has changed our views somewhat in regard to the needs of clothing, but has not yet thoroughly taught us just what the proper clothing should be.

For physical and mental efficiency it is necessary that the body be warm, clean, have unrestricted circulation of blood and unrestricted ability to breathe. Man, unlike other animals, is unable to live in cold climates

nor can white man live in tropical climates with only his natural coverings, but must depend on clothes for protection. If protection were the only requirement of dress the problem would be fairly simple, but fashion dictates how garments must be made entirely regardless of the health of the wearer. Then the individual tries to make them meet the demands of fashion and sometimes of hygiene as well.

Clothing which comes next the skin should be of such a character that it will help maintain a constant body temperature, will absorb and take care of the perspiration, give proper ventilation to the skin, and also be of such nature that it may be cleaned readily. It is important that the body be not overheated. In modern city apartments there is much more likelihood of this than of the other extreme.

A material to be warm need not necessarily be heavy or thick. The requirements differ for an outer and an under garment. An undergarment may be loosely woven, quite light in weight, and yet be warm. Still air is a poor conductor of heat, and the air which is held in the meshes of an undergarment is warm, gives opportunity for ventilation, and aids in evaporating the perspiration. In an outer garment a loose weave gives opportunity for the wind to pass through and allows too rapid a change of air underneath, and so is not warm. Several layers of light weight material are better than one layer of thick material, because of the layers of air held between them.

The warmth of a material also depends on the conductive power of the fiber from which it is woven.

Wool and silk are poor conductors of heat, cotton and linen better conductors. Linen feels cold to the touch, and is therefore pleasant for summer clothing. The conductive power of the fibers is not, however, as great a consideration as that of the amount of air inclosed in the meshes of the fiber.

The nature of the fibers, whether they will mat closely together or remain apart because of their elasticity and inclose air, also the weave of a fabric are very important factors in determining the warmth of a garment. Wool has this elasticity and makes a warm fabric, but after frequent washing the fibers become more felted together and harder, and the material is less desirable; this is especially true when it is carelessly washed. Linen and cotton may be woven with large meshes, but are ordinarily woven into close, thin materials, which are not very warm.

Heat is carried from the body in three ways: (1) By conduction by the still air or the clothing materials. (2) By convection, moving air which takes the warm air from next the body and replaces it with cold air which must then be warmed. (3) By the evaporation of perspiration.

The same characteristics which make a fabric warm give to it the ability to care for the perspiration. A loosely woven mesh material will absorb moisture more readily than one closely woven. The air in the meshes also aids in the evaporation of the perspiration. Sometimes there is danger of too rapid evaporation, therefore too rapid cooling, when the outside air has easy access to the undergarment. Those materials, like leather and

rubber, which allow no air to pass through prevent chilling by convection, but at the same time may become very uncomfortable because they do not permit the evaporation of perspiration and the skin becomes chilled by the moist garment in contact with it.

Thus far we have spoken almost entirely of keeping the body warm in cold weather. It is also essential to keep it cool in very hot weather. Garments which allow the rapid evaporation of perspiration and the removal of heat by convection are cool in summer. In the tropics special kinds of cloth which allow rapid passage of air are used by the white man. Special colors are also necessary, but the subject of color will be discussed more fully in a later paragraph.

The difference in the ability of fibers to absorb moisture without seeming wet is called their hygroscopic power. Wool may absorb thirty per cent of its own weight without changing noticeably in appearance; silk also absorbs much moisture without seeming wet. Cotton and linen have much less ability to do this. While wool absorbs a great deal of moisture it takes it up slowly; for this reason a layer of cotton next the skin, with a layer of wool just outside, seems to be very satisfactory. The cotton absorbs the moisture and passes it onto the wool, from which it is evaporated slowly, thus preventing rapid cooling of the skin. Undergarments are woven which carry out this idea; a thin knit fabric of cotton is combined with a thin fabric of wool in such a way that there is an air space between the two. This garment has also the advantage over all wool that it does not irritate the skin.

Probably few people in active life need woolen underwear; it is warmer than is necessary; it is irritating, and when one exercises the perspiration is not absorbed quickly enough and the skin becomes wet, a bad condition. Those who are leading a sedentary life do need woolens because their skin is not kept warm by muscular activity. Wool is also a good protection against sudden exposure and extreme cold, but it need not be worn in direct contact with the skin. Silk has many points in its favor; it is attractive, a poor conductor of heat, is easily laundered when pure, and absorbs water easily. The prohibitive feature of silk for most people is, of course, its price. With the present adulterations, aside from the union suits, hose, and undershirts, few silk materials fulfill all the requirements of a thoroughly hygienic garment next the skin.

To perform its functions most satisfactorily a garment must be clean, for the excretions of the skin clog the pores of the cloth touching it, just as they clog the pores of the skin itself if it is not properly washed. Ventilation and evaporation of perspiration cannot go on so well if the garment is thus clogged. Choice of material which is easily laundered is therefore important, and is another point in favor of cotton rather than wool.

Outer clothing has not so many essential requirements; its chief function from a hygienic standpoint is that it be warm in winter and cool in summer, and that it allow some ventilation. The outer clothing may be easily changed, and should, therefore, furnish the chief difference in warmth between dress in a steam-heated house and street dress. Furs are warm chiefly because

of the air held in and of the impenetrable character of the skin. They are warmer when the fur is worn inside, since it then holds a layer of still air. Furs swathed closely about the neck are unhygienic, as the skin becomes sensitive and colds are easly contracted.

Moist air conducts heat more readily than dry air, therefore on a damp, cold day there is greater need for active exercise or warmer clothing.

Color is an important factor in clothing only in connection with outside garments. The old tradition that red flannels are warmer than white has no foundation, unless it be that the red dye makes them a trifle more irritating. In outside clothing certain colors absorb more heat from the sun's rays; black, blue, green, and red absorb more, yellow and white less. Black also absorbs odors more readily. White reflects the sun's rays most, black least.

In the tropics outside garments are made from white materials and lined with dark green or some other dark color. Certain rays of the sun are reflected by the white, but others pass through. These are absorbed by the dark material, and the skin is thus protected. It has been supposed that the color of the black man's skin is a protection from certain poisonous sun's rays from which the white man must protect himself in an artificial manner. This theory is now questioned.

Summary

To summarize, clothing must be such that it will aid the body in maintaining constant temperature whatever the temperature of the outside air may be.

Clothing material must be of such texture that it not only aids in maintaining the right temperature, but also takes care of perspiration in such a way that the skin is cooled rapidly in hot weather and not too rapidly in cold weather.

The outside clothing must perform a function different from the under clothing, and so should differ in nature.

A thick garment is not necessarily the warmest one, neither need a garment be heavy. Light and warm are not opposing terms.

Access of air to the skin should be regulated, not prevented.

Free movement of the body should not be interfered with, neither should clothing be so warm that exercise is uncomfortable.

Cleanliness is all important both for the best functioning of the skin and for the comfort of one's self and one's friends.

Every person must decide what his or her needs are and dress accordingly. General rules cannot be laid down for all. Much is determined by living conditions, amount of exercise, age, health, etc. If not enough clothes are worn then more food is required, and the organs must do more work to keep the body temperature normal.

There has been a reaction from the woolens of the past, and doubtless some have gone to the extreme of not dressing warmly enough. Common sense, together with knowledge of bodily needs, will do much to improve conditions.

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CHAPTER XI

DESIGN AND COLOR IN TEXTILE FABRICS

THE problems of design and color in textile fabrics are somewhat complicated. No general rules for selection may be given, for there are many factors influencing the choice; among these are the use to which the material is to be put, the texture and cost of the material, and the individual taste. It is not the purpose of this chapter to go deeply into the theories of design and color, but only to give a few suggestions which may lead to further study or which may in themselves prove helpful in choosing artistic fabrics. A few foundation principles will be given, then a more general discussion of decorative art as applied to clothing and house furnishing materials.

Design

The terms and principles of pure design have been reduced by theorists[1] to simple denominations. Tone, measure, and shape are terms which define the units of a composition. The principles by which these units are combined to produce order and beauty are termed rhythm, balance, and harmony.

"Tone means the value (as dark, light) or the color (as red, green, blue).

"Measure means the size (as long, short, large, small).

[1] Notably Dr. Denman W. Ross, of Harvard University.

"Shape means the contour or bounding line (as straight, curved, square, round).

"Rhythm means joint action or movement, a consistent relation and connection of parts that enable the eye to find a way through all the details of a design.

"Balance means repose, that results from the opposition of attractions.

"Harmony means 'the consistency of likeness, having something in common.' 'A unity, all the terms of which are in interior accord.'"[1]

Rhythm is gained either through a gradation of tone from light to dark or from one color to another, through a shape which by its repetition or by its outline carries the eye along, or through measures which increase from small to large.

Harmony is obtained by a similarity of tone, or tones, having some common element, by a likeness of shapes, by measures either like or in some definite proportion.

Balance is obtained by the arrangement of tones, shapes, and measures in such a manner that there is symmetry between the parts.

With these terms and principles we have a number of possible combinations which may produce order. We may have one or all of the following present in a good design: tone rhythm, tone balance, tone harmony; shape rhythm, shape balance, shape harmony, or measure rhythm, measure balance, measure harmony.

Analysis of one or two designs may aid in illustration. In the photograph of a piece of Japanese silk the figure of the dragon illustrates measure rhythm from

[1]Batchelder, Ernest A. The Principles of Design.

the small scales at the end of the tail to the larger scales in the body. The scroll shape on the body is rhythmic in its gradually tapering points. There is rhythm of tone from the lighter tones to the dark ones throughout the figure. While there is no balance produced by opposition of like figures on two sides of a line, there is tone balance between the lights and darks, giving the effect of a medium tone to the whole. Tone harmony is illustrated by the repetition of the same tone in different parts

Fig. 39.—Japanese Silk

of the design, shape harmony by the similarity of contour, and measure harmony by the similarity in size of some of the scales.

The Persian brocade design illustrates the principle of balance more clearly. There is exact balance of shape, measure, and tone on the two sides of a vertical axis. Shape rhythm is also expressed in the leaves, buds, and vases, and tone rhythm is especially well shown in the birds near the vases. There is harmony in the shapes of buds, flowers, leaves, and scrolls, and harmony in tone in the different parts. The result is not only

entirely orderly, but beautiful as well. Unless some of these principles are observed in a design, order will not result, and it is not possible to have beauty without order. On the other hand, beauty does not necessarily follow order. There must be some beauty in the shapes chosen for the parts of the design, some inter-

FIG. 40. — PERSIAN BROCADE

est in the combinations of shapes, and excellence of execution.

COLOR

The importance of color in clothing and house furnishing is even greater than that of design. The effect of a good design may be ruined by poor color combination, and an excellent color scheme will do much to redeem a poor design. Color is ever present and deter-

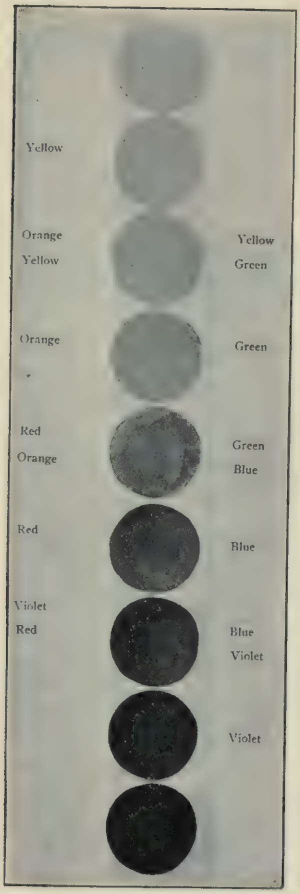

FIG. 41.—SCALE OF VALUES FROM WHITE TO BLACK

Colors in their greatest intensities correspond in value to spots opposite

mines the atmosphere of a room or costume. Color has a decided effect upon the nerves, although one is not always conscious of its influence.

As in design there are principles which aid in producing and judging good results, so in color there are theories which aid in the development of a good color sense. The science of color has been slow to develop, but of recent years definite scales have been formulated, which correspond to scales in music, and rules for color harmonies determined. The use of these scales is not very general yet. Only a few principles for producing color harmonies will be given here.

If a beam of light is divided by means of a triangular glass prism, the constituent parts when impinged on a white screen will show a band of colors. Beginning at one end with a deep crimson, this gradually shades into a brilliant red, which develops into orange, then into yellow, green, blue, and finally into

violet. This band of color is known as the solar spectrum and contains all color. The hundreds of variations of color found in nature and used by man are produced by combinations of these colors with each other or with black or white.

The effect of light produced by any pigment material or mixture of pigments is known as a tone. As has been stated above, each tone has two elements, the element of light or shade, which may be known as value, and the element of color or hue.

When we speak of value, we mean the amount of light present, or the absence of light. If we were to make a scale of spots, white at one end, and gradually becoming darker until we had black at the other end, we should have a scale of values. We should have absence of color, but a variety of light and shade.

The colors of the spectrum are as pure as it is possible to obtain color, and are therefore said to be in their greatest intensity; that is, the red is as red as is possible, the blue as blue, and so on. Opposed to this intensity is neutrality, in which we have no color. The scale of values between black and white is a neutral scale.

If now we should compare the colors of the spectrum with the scale of values, we should find that each color in its greatest intensity would correspond in value with one of the neutral spots in that scale. In those colors we should have great difference in value, from very light yellow to dark violet.

By adding black or white to any color, it is possible to lessen its intensity and change its value, so that we may produce any one color in all the different values of

the scale. These variations of the color are known as tints and shades. Again, between the color in its greatest intensity and the neutral spot of the same value there are a great many variations. As we neutralize the intense color, we have a series of tones, often known as

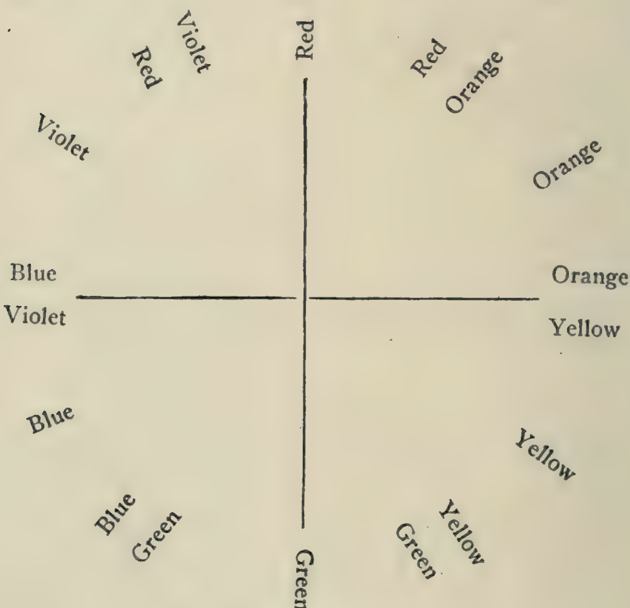

FIG. 42.—COLOR WHEEL

broken tones. These broken tones differ from tints and shades of the original color, in that they may either be of the same value as the intense color, or they may be of different values; but if this is the case they are not as intense as the tint or shade of the original color in that value would be.

If the six colors of the spectrum, together with the colors formed by the combination of any two adjacent colors, be put in a sequence, as in the figure, we should have a circle, in which each color is related to the one next it. This may be called the color wheel, and serves as a basis for study of color relations.

In examining this wheel it is readily seen that the colors near one another are closely related, while those farther apart have little in common. The colors directly opposite in the wheel have least in common, and therefore make the greatest contrast. These strongly contrasting colors are known as complementary colors. Combined in pure form, as found in the spectrum, they produce white light; in pigments they produce a neutral gray. Red and green, blue and orange, violet and yellow, are examples of complementary colors. Contrasting colors when placed in juxtaposition produce the effect of a greater difference than really exists. When properly used the contrast given by complementary colors is pleasing, though exciting, and must be used with care. Ordinarily one color is used in greater quantity than its complementary: thus there is not a struggle for predominance.

The combination of colors just next to the complementary is less contrasting than the complementary combination. The colors more nearly adjacent on the wheel have even more in common. As the interval between the colors becomes smaller, the contrast becomes less and less.

Very pleasing combinations of colors in this small interval may be produced: for example, greens and blues,

or orange yellows and yellows, or greens and yellows. On the red side of the circle the combinations are more difficult. The colors are very warm, and there is a greater difference between the reds and violets than between the oranges and yellows.

Used in their full intensities most combinations of colors on the wheel are harsh and unpleasant. There must be modification of the colors. Tints and shades and broken tones are most used in producing harmonies. This is especially true in clothing and house furnishing.

The combinations giving least contrast are those in which different tones of the same color are used. Here the contrast is only that of light and shade, or value. Care must be exercised that the different values are of the same or harmonious hues. For example, a light green, which was a very blue green, might not harmonize with a darker green which had a decidedly yellow hue, while on the other hand, it would form an excellent combination with a darker blue green.

The use of color must depend entirely upon the kind of effect which is to be produced. If a brilliant effect is wanted, intense colors may be used, and complementary contrasts will be in place. If a quiet, restful effect is desired, close harmonies, of broken tones, as browns and warm greens, will be chosen. A touch of a complementary may serve to relieve the monotony of a large mass of color or to increase the brilliancy of that color.

A rich result may be obtained by combining a number of broken tones of different colors, and the contrast may be lessened by having these colors very nearly equal in value of light or dark. A neutral background may

serve to harmonize a number of colors. Similarly a drapery of chiffon over a number of colors in a costume tends to harmonize these.

Certain colors have characteristics which cause them to be termed warm or cold. The red, orange, yellow side of the color wheel contains the warm colors, the violet, blue, green side the cold colors. The warm colors are those which seem to advance, the cold colors to recede. Gray is usually cold, but when it contains a large amount of pink becomes warmer. A cold color scheme may be relieved by a bright touch of a warm color, which if in small quantity may be quite intense.

The texture of material may aid in harmonizing color. The rich, deep pile of rugs with the play of light and shade on its surface serves to bring the colors together. Colors seem harsher and flatter in cotton cloth than in silks or wools. The brilliancy of lustrous silk may not be produced in wool, nor the richness of wool in linens.

Colors are greatly modified by others placed near them. One color brings out the hue of its complementary in the other. If one looks at a red spot for a long time and then looks at a white paper, a green spot, the complementary of red, will appear on that paper. If red is put next to blue, the blue will look greenish, because green is complementary to red, while the red will look more orange, because orange is complementary to blue. It will not be possible here to discuss the many variations produced by this juxtaposition of colors. Practice in combining colors will illustrate this point.

Skill in combination, unless one is a born colorist, requires long study and practice. Study of successful

color schemes, in rugs, pictures, fabrics, etc., is good training. Nature is an excellent teacher, but it is always well to remember that a brilliant touch of color with all outdoors for a background might be very trying when confined to the limitations of a room or of a costume. The proportion in which colors are combined is of great importance. When applying color and design in the decoration of construction, definite limitations must be recognized. For perfect harmony the small detail must be governed by the demands of the larger result. Both design and color must be subordinate to the whole effect to be produced. In architecture the farther the carving is removed from the eye, the less minute the units of its design. The size of the space to be ornamented influences the proportions of the details which are to fill that space. There are recognized positions for ornament, and ornamentation by small details is not appropriate for all parts of a building.

Certain colors are retiring in effect and may be used when the effect of space is desired; others advance and serve to bring forward parts to be emphasized, or to produce an impression of coziness.

General Principles

As stone and marble immediately place some limitation upon the kind of design to be used for their embellishment, so rugs and fabrics of various kinds place restrictions upon the decorator. Although wonderful machinery may weave practically any pattern which the artist's fancy creates, the nature of the material to be woven determines what kind of design is appropriate to

it. A dark, heavy fabric does not lend itself to delicate details, nor a filmy material to heavy design.

Conventional forms are the outgrowth of the limitation of materials. In picturing natural objects in basketry, the savage finds himself compelled to substitute square forms for curved, because his reeds are coarse and the lines of the weave are square. As the material becomes finer the limitation is not so great, and as man becomes more expert he finds it possible to develop more and more elaborate designs in his weaving. The height of perfection with the least conventionality is reached in tapestries.

The use for which a fabric is intended finally determines the kind of design which shall decorate it. A material which hangs in folds must have a different treatment from one which lies flat. Cloth which is to be cut in many pieces or broken by seams should not be covered with large patterns. A fabric forming a background must needs be quiet and retiring both in color and design, while that which serves purely as ornament may be much more striking.

There are two distinct methods of producing design in textile fabrics. In the one, the figure is woven into the material in various colored threads or with different weaves. In the other method, the design is stamped in color on the threads of the cloth either before or after weaving. There may be a combination of these two methods in one fabric, as when a design is printed on a cloth which has already been ornamented in the weave.

Design formed by variation of weave may consist of

lines, stripes, checks, or figures of the same color as the background. With the introduction of different colored threads in warp and filling the possibilities of variation become endless. The devices for varying weaves, for alternating colors, become almost superhuman in the Jacquard loom, and the results produced are marvels of mechanical skill.

Printed designs are somewhat more limited in color, although even here a wide range may be obtained. The pattern used is restricted only by the limitations of wood carving or copper engraving.

In fabrics used for clothing, the plain, unfigured cloth is frequently most satisfying, lending itself well to tucks, folds, and seams. The beauty of plain cloth, however, depends for its charm entirely upon the texture. When the texture is not rich, lines, stripes, or figures add interest. With the hard-twisted threads of worsteds, if the surface is broken by diagonal twills, almost invisible though they may be, pleasing results are produced. Introduction of a little color in a hair line or a cross marking leads to greater variation in stripes, checks, and plaids. Variety thus gained adds interest to dress and offers greater possibilities in color combination. The dictates of good taste are to choose from these stripes, checks, and plaids the inconspicuous and those suited to the individual figure, leaving the strangely peculiar styles to those whose chief claim to distinction lies in the loudness of their clothes.

Figures in cloth, beginning with the simple dot, a mere variation in weave, become more and more elaborate, growing into scrolls, flowers, bouquets, vines,

trees, finally landscapes and architectural representation. Possibilities of great beauty are opened, and also abundant opportunity for the exercise of poor taste. The offerings of the market express well the status of public taste. In contrast with the many really beautiful designs exhibited in the best shops are found hundreds of designs with nothing to commend them, unless it be that they are "different."

As has been said design in clothing materials must be much limited by the comparatively small surface to be covered and by the lines of seams and folds which break that surface. The richness of heavy silk may be increased by a damask pattern in the same color, which gives an added play of light and shade on the lustrous threads. In this case the design may be quite large, but not too complicated, as the figure is partly lost in the luster of the surface. No other material offers equal possibilities. Linen with the same sort of design gives beautiful effects for table use, but is too stiff and unwieldy, when so ornamented, for beauty in clothing material. Wool lends itself to such design only under exceptional conditions when the character of the fiber has been altered by chemical treatment, and it is then too wiry for clothing. Cotton has not that inherent beauty of texture which makes damask designs excellent.

Soft cottons and silks are very attractive when decorated with bouquets of flowers, even if these are quite large; a pleasing color effect is obtained, combined with delicacy and gayety. The same pattern executed in heavy materials would be most inappropriate, or in dark tones would loose its charm. Simple all-over pat-

terns of the same color or closely related colors are pleasing in different textures provided they are not too large or too intricate. Oriental patterns, which are combinations of geometric designs and conventionalized natural forms, may be good on silk or more simply executed on cottons.

The field of design in dress materials is therefore limited to a few types, variation in weave, lines, stripes, plaids, checks, more or less complicated spot designs, and rather simple all-over designs being the most suitable forms.

Another field for design in dress is that of accessories, rather than of the dress as a whole. Here greater possibilities lie before the designer. A band, a bit of embroidery, or a medallion, to be used in small amount, may be much bolder in treatment than the material from which a whole garment is made. Stronger colors and larger figures are permissible, and there is greater opportunity for the exercise of imagination and skill. The main fabric of a garment must be rather conventional, but the ornament need not be limited by such narrow bounds. In these accessories of trimming, strength and character of both color and design are required. If the trimming is to add distinction to the dress it must have qualities which make for distinction.

In the selection of house furnishing materials the choice of design is much more varied. The surfaces to be covered in rooms are larger, the effect as a whole is less limited, and there is greater opportunity for skill in combining colors and in design. Here again, if the best results are to be obtained limitations must be recognized.

Frequently because of the choice of large figures and strong colors in wall paper a room is made to look small. The design in a rug may seem to rise up and greet one on entering a room. Confusion may be the result of too many figured surfaces.

Each type of furnishing material imposes its limitations on design. The hanging demands design that is not spoiled by folds. Where a diagonal stripe would be broken and would give an unpleasant effect, a vertical or horizontal stripe would be successful. Figures which break the surface and give variety of color but do not depend on being seen in their entirety are more successful than carefully developed designs which lose their charm if partly hidden. Similarly, fabrics for upholstery may be much less definite in design, because the surface is broken by buttons and the folds around the buttons. Rather indefinite foliage patterns give pleasing color variation and variety of surface, and are not dependent on large spaces for a good result.

Wall coverings or flat hangings have quite a different purpose to fulfill. They must either form a background for pictures and furniture, or they must furnish decoration. In case a background is desired, plain surfaces, two-toned designs, or simple, unobtrusive patterns are most satisfying. The wall covering should be of such nature that it will not dispute with the pictures the right to be noticed. When decoration in a narrower sense is demanded of this covering, it must possess some real value as design or as pictorial art. In houses of moderate means it is rarely possible to afford this latter type of wall decoration. In screens, sofa cushions, couch

covers, and possibly in window hangings there is opportunity for expression of a love of the more unusual, the gay and the bolder design, by a bit of Japanese print, Oriental cotton, or gay English or French chintz. If the pocketbook can aspire to embroideries, there are many beautiful bits of imported silks and satins, exquisitely worked, which add a tone of richness to an interior.

The charm of Japanese designs lies largely in the grace and motion which they are able to express in the portrayal of the simplest objects, the fitness of their designs to the object decorated, and their exquisite use of color. In introducing Japanese designs into our houses, we should always bear in mind that in their native environment they are not crowded in with a great many other things, but have space enough to be appreciated.

The rug seems to furnish the most difficult problem to American manufacturers. We have already departed from the age of green dogs and purple cabbages in rugs, and are now emerging from the age of pink roses. The Persian and Turk have taught us that designs suitable for rugs must be of such a nature that they do not thrust themselves on the attention at once, but give variety of color and richness of surface without being immediately evident. Geometric and highly conventionalized forms in not too large units are desirable. Considerable variety in the design in order that the units need not be repeated at too frequent intervals produces a more pleasing result than constant repetition. Certain makes of rugs are limited in design by the mechanism

of their weaving, but the better grades have practically no such limitation.

It has taken a long time to begin to teach the lesson of good taste in rug design, and the fact that it is now being appreciated is probably due to the great popularity of Oriental rugs. The design of these rugs may be copied by machines (although it becomes too perfect in the copying), but the lesson of color is still to be learned from these magic rug makers.

The subject of color and design offers a most attractive field for study, and one which is ever present. Observation of birds, trees, flowers, and other natural objects is a pleasure, and affords endless suggestions of form and color which may be adapted to decoration. Simplicity is a good watchword, for over-decoration has been a failing of the age.

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CHAPTER XII

LABOR CONDITIONS AND EFFORTS TO IMPROVE THEM

THE United States Government is publishing a report of nineteen volumes on the condition of woman and child wage-earners in the United States. The size of this report suggests the vastness of the labor problems of the present day. The textile industry, aside from being one of the greatest manufacturing industries, employs a large percentage of woman and child laborers. A study of textiles would therefore be incomplete which did not at least touch upon the problems of these laborers and tell of some of the reforms which have been or are now being accomplished.

Ever since the development of the modern factory system it is the women and children who have been least protected and who have suffered most from the system. Unorganized, without a voice in the making of laws, physically at a disadvantage, they have been able to do little for themselves. Labor unions and power in legislation have been able to demand certain rights for men, but even they have not accomplished all things, as is shown by the prevalence of strikes and the fact that we have a "submerged tenth" in our population. It remains for the twentieth century to realize more fully that the people as a whole, the community, the state, and the nation, must protect the working man, woman, and

child, and through them protect the future citizenship of the country.

Investigation of the problem shows that it concerns not merely the age at which the law shall allow a child to work, but where, when, and under what conditions the child, the woman, or even the man shall work. What wage shall the worker receive? what protection from machines? how many hours a day? If the child is shut out from the mill, how much time must he spend at school and what shall the school teach him? These are a few of the questions which have arisen. To understand them it is necessary to have some appreciation of conditions. Although the old systems of hand industry abroad often meant poverty, filth, disease, and all sorts of human suffering, in some respects the modern factory system has made conditions worse. There have been added the congestion of population in tenements and the never ending routine of highly specialized work for the individual, the nerve-racking noise of the factory and the terrible rush of competition. The possibilities of machinery are boundless, but if machinery is to do the greatest good for the human race it must not be at the expense of the bodies and souls of the human beings who tend the machines.

In Europe and in America the factory system in a simple form came into existence long before the invention of machinery. In England, after the Flemish weavers had introduced fine weaving in the time of Henry I, these weavers lived and worked together in communities. Guilds had their beginning before the Norman conquest and flourished all through the Middle

Ages. They were organizations of different trades, and became very powerful. They controlled industries, regulated prices and wages, and frequently took the initiative in suggesting laws for the benefit of trade. The craft guilds protected the workman and the interests of the various crafts, much as the trade unions protect the interests of the workingman today. Often there was bitter feeling between guild members and non-members. So restrictive had the power of guilds become by the time of Henry VIII that they then began a rapid decline.

The wealthiest manufacturer of this time was said to have had a hundred looms, but very few improvements had been introduced in the methods of manufacture. The introduction of improvements from abroad was strongly opposed, the protection of home industries and hand labor being intense. Laws limited the size of the flocks one might own, the amount of time which it took to tan leather was not allowed to be lessened, and many other similar regulations existed. While the living conditions of those who spun and wove were frequently very miserable, it was not at all uncommon for a laborer to rise to be a successful merchant and become a knight of trade. In the reign of Elizabeth conditions were better in England than in surrounding countries. The eighteenth century brought in the use of machinery and revolutionized methods. By 1812 and 1813 in England the introduction of machinery, together with continual wars, had brought about terrible suffering among the laborers. Doubtless the factory system alone would have done much, for the English capitalists saw here increased opportunity for becoming rich.

"The factory system that was then established completely changed English industrial methods; the workers were huddled together in unhealthy factories, compelled to work from early morn till late at night, and, what was the worst feature of the system, young children of tender years were set to toil in the mills under such hard and repellent conditions that their constitutions were undermined, and a race of working people grew up stunted in body and weak of constitution. So bad had things become that, in 1802, an act was passed for the benefit of the 'health and morals' of apprentices and others employed in mills, and the hours of work were reduced to twelve per day."[1]

This law of 1802 related to cotton mills and was the first factory act. The abolition of slaves in 1807 freed the negro, but the slavery of the factory worker was not broken for many years. In 1847 the Ten Hours Bill, which was debated for fourteen years before it could be passed, became a law, and since that time legislation in England has advanced continually.

Factory legislation in this country came much later, partly because factories were not erected so early here and bad conditions did not develop so rapidly. The long struggle for legislation and the attitude towards these problems may be better understood if we trace briefly the development of this field of labor for women and children in the United States. In the early days women had a place in the home which demanded all their attention. Children as well as grown women helped with the spinning and the many other household tasks.

[1] Burnley, James. The Story of British Trade and Industry.

The chief manufacturing industries of the colonies for many years were those carried on in the home, and women had comparatively little place in outside industries. A few were employed in shops, some in taverns, some in business enterprises, but the majority of those who had not a home of their own went out to service, and thus were employed in the industries of another household. The attitude of the early New England colonists towards women and children was very severe. They were not permitted to be idle, if they were poor, but were forced by public opinion and by law to do something for a livelihood. Children were bound out as apprentices. This meant to girls about the same thing as being bound out to household service, since the trades they learned were spinning and weaving and other household industries. The United States was much slower than England in developing power machinery. There was a long period during which spinning and weaving had in part gone out of the home, yet the later factory system had not come. In the cities societies "for the Promotion of Industry" were organized under private or public management. From these centers work in spinning was given out to women at home or at the manufactory. In some establishments many looms were operated; in others the yarn was sold for home weaving or to other factories. Thus, employment might be given to a whole community, or to the almshouses, and the poor kept busy. This was the first step in the great movement of women from the home to the factory. Small children from eight years up were employed in these establishments, and it was considered

an excellent thing that children could thus be kept from idleness.

With the development of power machines and great factories for spinning and weaving, and later for garment making and the food industries, it was natural that women should follow the industry from the home and take their place in the mills.

The conditions under which women worked in the early days of power machinery were little better than they are today, for the commercial spirit developed early; but the attitude of women toward the conditions was very different, and the class of workers was different. Many women were in industry temporarily, to earn money to go to college or to earn spending money. The great rush of modern competition had not begun, and the factory town with all its squalor and ugliness had not developed. The century which has passed since has added these and has given a different face to the problem.

Factories grew much faster than laws for their regulation. The increase of child labor was so great that the results were soon visible in stunted adults; and yet long hours and night work for children, preventing proper physical and mental development and instilling in the minds of the children low morals, have been allowed for more than a hundred years by so-called highly civilized nations.

Crowded factories, with unprotected machinery, have meant death or the maiming for life of many thousands of men, women, and children. Bad sanitary conditions cause not only physical harm, but often moral degeneration.

Rapid immigration into America has helped to produce a system of manufacture which has been called a disgrace to the nation. The press of competition led men to employ these newly arrived immigrants at the lowest wages, herd them together in cheap workrooms, and work them long hours. As competition increased, it was found that money could be saved by letting these people take the work to their own homes, if homes they might be called. In the dark, foul rooms of the tenements, the sick and those too young to go to the factory might work at starvation wages, sometimes infecting the garments they were making with the germs of terrible diseases. Meanwhile the purse of the manufacturer grew fatter and fatter. Thus the sweat shop system grew and increased, and thus it still exists.

One might write on and on, of conditions around factories, of the hovels in towns and villages where workmen and their families are huddled together in filth, without a tree or a blade of grass, with not even fit water to drink, and with the very air they breathe made poisonous by the gases of hundreds of chimneys. Low wages, fire traps in which to work, no schools because the children must work long hours, all these things grind down the lives of men, women, and children who are the producers of the world.

Not only among producers have these bad conditions existed, but among distributers as well. It was the condition of women in the shops which first aroused the united action of women in New York City. There again, long hours, low wages, bad sanitary conditions, no provision for chance rest during working hours, no rest

rooms, no decent places for lunch, inhumane treatment from employers, and the employment of child labor were the most striking evils.

That all of the conditions mentioned exist today in factory and in shop, in one place or another, is a well recognized fact, but the fact that they have been improved in many cases is also recognized. The first legislation in this country to regulate labor in factories was an act passed in Massachusetts in 1842 prohibiting the employment of children under twelve years of age for more than ten hours a day. In 1848 Pennsylvania passed a law forbidding children under twelve to work in cotton, woolen, silk, and flax industries; in 1849 this was made to include bagging and paper industries, and the age limit was raised to thirteen years.

Prior to 1860 hours of labor for children in industry were reduced in the states of Maine, New Hampshire, Massachusetts, New Jersey, Pennsylvania, and Ohio to ten a day. The age limit differed in these different states. At the same time laws were also passed in these states and in Connecticut requiring a certain amount of schooling. Usually the law required three months out of twelve, but varied in different states in regard to length of time required and the age of the child. At first there was no provision for the enforcement of these laws, no factory inspection, and no requirement as to proof of a child's age was made. Consequently the laws amounted to very little.

Gradually, however, there has developed a sentiment for better conditions, which has slowly increased inspection and regulation, vitalized compulsory educa-

tion, and changed the attitude of legislators towards these things. It was not until 1898, however, that the first law placing the age limit for child labor at fourteen years was passed, and even that limit has not yet been reached by many states.

There have been a number of forces working to bring about this legislation and to improve methods of inspection and enforcement. Great numbers of statistics have been collected to show the effects of long hours, poor wages, and unsanitary conditions, and volumes have been written on the subject. Public lectures, free literature, and various methods of interesting the general public have been tried, and yet progress is slow. General enlightenment in regard to sanitation and hygiene has carried a demand for better conditions in all public places. The development of the educational system, with its compulsory education laws and its truant officers, has taken many children from the factory. Changed methods in the schools, the introduction of new subjects, as manual training, have given an added interest and kept the children in the schools for a longer time. It has been found that factory laws do little good unless there is factory inspection also, and this has been greatly increased.

Not all betterment of conditions has come from the outside, however. In many cases, realizing that better work results from good conditions, the factory owners themselves have improved their work rooms, provided good homes, libraries, gymnasiums, club houses, and other comforts for their employees, expressing at the same time a sense of their responsibility toward those less fortunate than themselves.

Conditions of factories, child labor, low wages, long hours, and bad moral influence are deplored by most enlightened people, but deploring bad conditions does not remedy them. In recent years many organizations have sprung up for united effort of one sort or another to bring about certain ends. One of the most potent agencies for improvement in working conditions has been the National Consumers' League. The outgrowth of the formation in New York, in 1890, of a group of intelligent women who sought to reform conditions in retail stores has become a nation-wide movement working in many fields. In 1898 the organization was incorporated as the New York City Consumers' League. In 1899 the National Consumers' League was founded, and it was incorporated in 1902. The purpose of the League is to educate the consumer to find out the conditions under which the product is manufactured in order that he or she may be protected, and at the same time that the conditions of working women and other employees may be improved.

To many people the problem of buying means merely getting the worth of one's money in the thing purchased. This money's worth may be in wearing quality, in color, design, texture, in fashion or fad, according to the needs and the demands of the individual buyer. The knowledge that diseases may be carried through ready-made clothing has put another responsibility upon the family provider, who must now see to it that she does not buy tuberculosis, smallpox, or any other dread disease along with the garment she purchases. The laws of economics teach that demand determines supply, that each person

who buys does just so much towards setting the standards for good or poor supply. The manufacturer must meet the public demand, not only in kind of material, but in price. In the effort to produce cheap material, cheap labor is employed, conditions of work are poor, and work is sent out to places where it may be done more cheaply. The buyer can insist that what she buys is not contaminated with disease germs and does not represent the life blood of the poor. The intelligent women of the future must realize this responsibility.

The New York Consumers' League, with this truth in mind, began its work, not with the factory, the center of production, but with the retail store, the center of distribution. The store was more within reach of the shopping public. From the store the League went to the factory.

The National Consumers' League has expanded from year to year. The field covered by its efforts has increased. It has endeavored to improve conditions in stores, tailors' shops, ready-made clothing and other factories; has worked for pure food laws, for sanitary handling of goods, for child labor legislation, for laws regulating women's labor, for the abolition of sweat shops, and for many other things. An organization of this sort, which has no direct power to make laws, must work in a scientific way to accomplish any great results. Investigation of conditions and the accumulation of facts are first necessary; after this, intelligent interpretation of these facts, publication of results, and the arousing of public interest aid in bringing about legislation.

When the Consumers' League began its work there were in many states laws regulating factories and other industries, but these laws were often inadequate and were not enforced. The lack of factory inspection so evident today was much more evident fifteen years ago. While some states were enacting excellent laws, many had done nothing at all.

Through the efforts of organizations and individuals matters have been much improved and excellent legislation has been passed in all parts of the country, but the work is only begun. Laws are not at all uniform in different states, which complicates the situation. The press of competition makes it extremely difficult for one factory to live up to high standards when a factory in a neighboring state is paying low wages, working long hours, and employing child labor. The American Bar Association has recently given a great deal of attention to the securing of uniform state laws of various kinds.

One method by which the Consumers' League has put a premium on the best factory conditions is by giving to the manufacturer who lives up to certain standards a label to be attached to his goods. The label provided by the League, and pictured here, insures to the buyer that goods so marked fulfill the following requirements:

1. Clean and safe workrooms with good sanitary conditions.

2. No child labor.

3. No work outside the factories.

4. Proper working hours.

Those who insist on buying goods marked with the

Consumers' League label protect themselves and their families from the danger of buying garments made in filthy homes and by diseased workers. They protect the worker from unlimited hours of work and from the lowest possible wages. They insure against the labor of little children and decrease the danger from tuberculosis.

This label is granted only after careful inspection, and its use means continued inspection by the Consumers' League.

Up to the present time the label has been limited to women's cotton underwear, wrappers, cotton dresses, and

FIG. 43.—CONSUMERS' LEAGUE LABEL

a few other ready-made garments. These seemed to be the best lines to begin on, partly because so many women are employed in making them. As funds are available, and as it is feasible, other kinds of garments will be included.

In some states the League has a list of approved tailors. The requirements are much the same as those for factories. The work, with the exception of embroidery, is all to be done on the premises or in approved workshops, the requirements of factory inspectors must be met, and the conditions of the workrooms must be fair.

One of the best results accomplished by the League is that many merchants have learned that it is economy

to treat employees humanely, to pay living wages, to give vacations on pay, to give Saturday afternoon holidays, and to provide decent rest and lunch rooms. The shop girl who has these things done for her sells more goods than the girl who is worked long hours and has no chance for rest.

The Consumers' League has a White List, in which the names of all stores and factories which come up to the requirements of the League are printed. These requirements are as follows:

I. Wages:

1. Equal value to receive equal pay regardless of sex.
2. No saleswoman over eighteen years of age to receive less than $6.00 a week.
3. Wages paid by the week.
4. Minimum payment to each child $2.50 per week.

II. Hours:

8.00 A.M. to 6.00 P.M. Three-fourths hour for noonday lunch, one half holiday per week during two summer months.

Vacation of one summer week on pay.

All overtime compensated.

Wages paid and premises closed for five legal holidays.

III. Physical conditions:

Lunch and retiring rooms apart.

Sanitary conditions.

Seats for saleswomen.

IV. Other conditions:

Humane treatment of employees.

Length of service compensated.

No children under fourteen years employed.

No children under sixteen years employed for more than nine hours per day.

These children from fourteen to sixteen years shall have employment certificates from Board of Health.

All city ordinances and state laws must be obeyed.

The League wishes to make it a good advertisement for a store to be on the White List or to carry a large stock of Consumers' League labeled goods. It is hoped that people will buy at the stores which are so advanced. If the public would learn to demand these things the manufacturers would soon come up to the requirements.

Although the list of factories and stores complying with all the requirements of the Consumers' League seems small, it grows year by year, and there are many other concerns which fail to meet the requirements only in small ways.

One of the requirements of the League, which excludes many stores from its White List, is in regard to uncompensated overtime at the Christmas season. "Only the long, slow process of public education will remove the custom whereby thousands of young girls and women are compelled every holiday season to give their employers from thirty to forty hours of uncompensated labor."

Much literature has been published advocating early Christmas and early afternoon shopping. These appeals in the papers, by posters and by many other means

have brought about a little more thoughtfulness in these matters.

Investigation into the working and living conditions of women in factories has led to many results. A strong body of women has been formed who demand legislation and have succeeded in obtaining it. The development of legislation regulating the number of hours of work for women has been most encouraging since the Supreme Court of the United States, in 1908, asserted the right of states to limit the hours of labor. In Oregon, Illinois, and Michigan there have been epoch-making decisions in cases where the law limiting hours of labor was declared unconstitutional by a lower court and the decision reversed by the Supreme Court. These decisions have paved the way for similar laws in other states.

At present one of the most important investigations carried on by the Consumers' League is in relation to the minimum wage problem. The work of the special committee "has been directed toward two ends: (1) Agreement upon a legislative program adapted to the peculiar American conditions; (2) publicity for the proposal to establish minimum wage boards."

The limits of this chapter do not permit a longer discussion of the far-reaching work of this organization. Full reports and articles may be obtained from other sources.

The National Child Labor Committee, organized in New York in 1904 by a number of representative citizens from different parts of the country, is a force which is making itself felt in child labor legislation. This committee investigates facts regarding child labor, en-

deavors to raise the standard of public opinion and parental responsibility, and assists in protecting children by suitable legislation.

It is now practically agreed that a humane child labor law shall provide the following:

A fourteen years limit, below which children are not to be employed.

Regulation of work of children below sixteen years, including:

Prohibition of night work,

Shortening of hours by day,

Protection against dangerous machinery and unsanitary or immoral conditions.

There should also be compulsory school requirements, and there is necessity for inspection and enforcement of these laws. A few states have reached this high standard; most have not.

In April, 1912, Congress passed an act creating a Federal Child Bureau which shall collect statistics regarding children and conduct a thorough study of all sorts of child problems. From this center information will be disseminated to all who need it. The National Child Labor Committee worked very hard for this bill.

With the growth of the public health movement additional agencies are working for an enlightened attitude toward many great national problems. The study of preventive medicine has led to housing reforms, better sanitary conditions in public buildings of all kinds, the abolition of the public drinking cup, and the investigation of water supplies. The great need is for education in order that the public may come to know that these

things must be. The slowness of legislatures in passing laws merely reflects the attitude of the people as a whole.

Long and tireless effort must be put forth by the enlightened men and women of the country in the future as it has been in the past. New ways of spreading information are ever arising, more and more scientific methods of investigating and solving these great problems are appearing as the thoughtful men and women of the country give their lives to the cause of race improvement. It is no longer a question of charity, to ease one's conscience, or even for the sake of the poor alone. The problem of the less fortunate becomes the problem of the whole nation.

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CHAPTER XIII

THE ARTS AND CRAFTS MOVEMENT

THE introduction of machinery for the manufacture of almost all articles necessary to satisfy human needs and desires began an era of decline in the beauty and the honesty of useful things. Painting and sculpture rapidly came to be considered the only real art, and it seemed that before long nothing else would be worthy the name. Textile fabrics, house furnishings, the tools of man, and public buildings alike became more and more marked with the term machine-made. Individuality was lost, while over-decoration, sameness, and uselessness were growing factors. In the second half of the last century, a group of English artists more far-sighted than their contemporaries became alarmed at the state of affairs and set out to awaken men to a realization of what was happening.

This group of men saw that, unless a reaction took place, machinery would destroy all art in every-day things, flood homes with unartistic bric-a-brac and cities with ugly ornamentation, and cost would be the criterion by which all things would be judged. The whole tendency of the system seemed to be toward ugliness rather than toward beauty. In searching for an understanding and a remedy for these conditions they turned back to mediæval times, to a period entirely different from the one in which they lived. Here they sought the secret

of beauty in every-day things. They found that when handicrafts were at their best in the Middle Ages the simplest tools and household articles, while often clumsy, were honest in construction and frequently marked in their beauty. The individuality of the worker was expressed in his products and the nature of the material was respected.

As machinery increased the output and made cheaper and cheaper products, honesty of material became more rare, the individuality of the workman was lost, and fad and novelty were replacing real artistic merit. The very fact that ornament could be produced cheaply led to great profusion of it, and over-decoration of all kinds resulted. Machinery was doing away with the craftsman, and man was forgetting how to make things with his hands.

Out of this period of degeneracy in useful arts the voice of Carlyle in England came as the first warning which set men to thinking. Believing thoroughly in the value of work and the effect of honest labor and honest production upon the character of man, he deplored the state of the manufactures of his time. He pronounced the goods of his day "cheap and nasty" and "tainted with the spirit of Mammon." "If I want an article," he said, "let it be genuine at whatever price; if the price is too high for me, I will go without it; unequipped for the present, I shall not have equipped myself with hypocrisy at any rate."

Carlyle preached the doctrine of work, the education of men to do things, and to do them honestly. He did not by practice attempt to alter the methods of the times,

but his writings inspired others. He saw that the old era had passed, when men could stand idle, and that a new industrial era had arrived, in which work was to be the chief duty of man.

Ruskin, following after Carlyle, was influenced by his writings. A man of wide interests and studies, he was a socialist and much dissatisfied with the existing order of things. He saw that art was getting far away from nature and was becoming degraded. He deplored the fact that art and the crafts were so far separated in the new system of machine production.

Believing that great art is produced only out of pure national faith and domestic virtue, and that artists must be workmen and workmen artists, he saw that the social problem must be the point of attack. If workmen are to be artists, they must have the education, the surroundings, and the happiness which will enable them to produce beautiful things. The true test of art, he considered, should be its serviceability to social needs. It must be universal and lowly. Not only should art be the product of all men, but it should serve all men. The office of machinery, according to Ruskin's ideas, must be to do things for man, to relieve him of drudgery and debasing work, but artistic work must be the work of the hand. He saw that minute division of labor was deadly to the workman and to the product. Though there was an increase in quantity produced, there was a decrease in quality.

Ruskin believed that every man must work to be happy, but he says: "In order that people may be happy in their work, three things are needed; they must be fit

for it; they must not do too much of it; and they must have a sense of success in it." The reward for work was to be not in the money received for it, but in the satisfaction of having done well. He believed that through education reform would come.

A man of great genius, an artist, and a writer on many and diverse subjects, it is easy to forget that sociology was perhaps Ruskin's chief interest and that he hoped to achieve social reform through industrial reform. He approached the subject from so many sides one does not always realize that the social problem was the one at which he worked hardest. Ruskin went beyond Carlyle in that he put some of his theories into practice and spent a large part of his fortune on his schemes.

The revival of home industries, where workers might "engage in some useful craft under wholesome and humane conditions," was one of his ideas. Home industries were to exist side by side with the factories, not to supplant them. Some of these industries were started by him and still flourish. In the Isle of Man and in Westmoreland he revived spinning and weaving and encouraged handwork among the cottagers. This work has proved not only pleasurable but profitable, and some very excellent products have resulted from his beginnings.

In 1848, at Oxford University, there was formed a society of painters, sculptors, and writers, the Pre-Raphaelite Brotherhood. These men were destined to have a great influence on art and literature. Their chief doctrine was a fidelity to nature and a sincerity in practical work. Their influence was to be felt later in useful as well as in fine arts.

A few years after this Pre-Raphaelite group was formed at Oxford, William Morris and Edward Burne-Jones came as students to train for the ministry. Inspired by Carlyle and Ruskin, these two and a few other fellow-students read, discussed, and thought. They also worked and wrote. The profession for which they had begun to train was forgotten and they set about to become artists, not artists merely in the sense of painting pictures, but in a more general sense.

In the field of art in textiles and house furnishings, Morris has been most influential, although inspired and aided for years by Rossetti, Burne-Jones, and others. The extent of Morris's work was marvelous. It has been said that he accomplished more than seven ordinary men.

Beginning as poet and painter, he studied architecture at Oxford. On going up to London he deplored the condition of the houses of the period. When he found it impossible to buy any furniture that he would have in his rooms, he had some made from his own designs. When the furniture was built, Rossetti painted the panels for him. The result was rather mediæval, but was a start in the direction of better lines and greater usefulness.

Later, when he was to be married and wished a house to live in, he found he must build the house and everything which was to go into it, so impossible was it to satisfy his artistic taste with the degraded decoration of the English market. Red House, as he called his home, opened a new era in house decoration. Appreciating the facts that a house is built for the needs

of the owner and that the individuality of the owner may be expressed therein, every bit of construction, decoration, and furnishing was carefully worked out in order that Red House might be truly his own. Although Philip Webb was the architect, through the work of decoration and furnishing Morris first showed his wonderful skill as a workman. In whatever medium he was moved to work, he proved himself master. Wood, glass, plaster, clay, leather, textile fabrics, and wall paper, all had their turn. Bookbinding or tapestry weaving, he put his whole heart and soul into the work, and his results were wonderful.

In 1861, as a result of their coöperation in Red House, Morris and his fellow-artists established the firm of Morris, Marshall, Faulkner & Company, Decorative Artists. Associated with the firm were Rossetti, Ford Madox Brown, Burne-Jones, Philip Webb, and others. They advertised to do work in glass, wood or stone carving, pottery, metals, embroidery, and furniture. At first an experiment in a new line, the work of the firm soon became known, and their beautiful windows, tiles, etc., gained a place in the best churches and private houses of the time.

Later, interested in producing beautiful prints on cloth or on wall papers and in reviving the tapestry and rug weaving industries, workshops were established in London and then at Merton Abbey, where hand weaving, dyeing, and printing were carried on. The Merton Abbey workshops had the advantage of abundance of sunlight, fresh air, and beautiful country environment, excellent attributes for the production of artistic work.

The whole spirit of Morris's works and writings emphasized the necessity of better conditions for the workman, higher ideals for the product, and the existence of beauty in the most commonplace things. Sham work he believed to be hurtful to the buyer, more hurtful to the seller, but most hurtful to the maker. He felt that the age of machinery had brought the competition of cheapness rather than of excellence, that a great change must take place in the public attitude toward art and industry, and that the two must be more united if the hideousness of the age was to be at all lessened.

The whole life of Morris, the study of his writings and his work, is an inspiration to all those who are interested in making the world more beautiful, in raising the standards of art in every-day life, and in bettering the conditions of the worker. There have been few men who have accomplished such a mass of work in a lifetime, few who have left their impression on so many fields of human effort. He was a poet, story-writer, essayist, socialist, printer, bookbinder, illustrator, painter, designer, carver, potter, weaver, dyer, leather worker, embroiderer, glass worker, and metal worker. How many men could add as many trades to their name? The most wonderful part of it all is that Morris was skilled in each. He has been the inspiration for the best that has been done in decorative art for nearly a half century, the force that set England, America, and most of Europe thinking and turned the tide of the fast disappearing handcrafts.

The Arts and Crafts movement in England and America is one outgrowth of this new interest in ap-

plied arts. In the minds of many, Arts and Crafts means merely shops where hand-made articles are offered for sale, or it may be the name brings to mind a type of ornament represented by the severely plain, straight-line candlestick or writing set, the stenciled crash table-runner or pillow top, the simple rag rug, etc. The movement has sometimes come into disrepute because it has been judged solely by these things, which in some cases have little or no real artistic value.

A true understanding of the significance of the movement requires some investigation into the broad field of its work. As the name implies, Arts and Crafts is an effort to associate art and industry; not an effort to do away with machinery, but rather to encourage individual expression in the craftsman's work and to bring beauty into the every-day things of life. It is an outgrowth of the effort to draw away from the bad designs, over-ornamentation, and poor workmanship of the factory age, and to return to simplicity and beauty in workmanship.

Realizing that the expression of art is not restricted to painting and sculpture, the effort is made to bring truly beautiful furnishings into the homes of all, and to create the desire for the beautiful and useful, rather than for the over-ornate and useless. By thus creating a demand for the artistic, the workman who can make beautiful things will be given an opportunity to express himself in truly individual work. There are many people who have not the great genius necessary to produce wonderful paintings, but whose skill might find expression in the lesser arts. These men who know and are

true to the material, the construction, and the tool find pleasure in work, and the thing produced is its own inspiration and its own reward. Yet we all must live, and there must be sufficient money compensation for our work.

If hand-made articles produced under the desired conditions are to command a good price, the public in general must be educated to appreciate the value of honest workmanship, to appreciate beautiful materials and simplicity, and to demand the few things, excellent, rather than the many, poor in quality. Therefore a movement such as we are considering must educate not only the worker, but the public as well. The buyer must be able to distinguish the good from the bad. Not all handwork is good, although in the fad for such work anything hand-made is prized by many.

In its development, the Arts and Crafts movement has worked along various lines. In England there are several methods of expression, among which are the production of works of art craftsmanship by individuals, by schools and lectures, by communities, by exhibitions and museums. Village industries have been developed in which weaving, pottery, metal, leather, and other handwork is carried on. Museums in connection with these industries furnish inspiration, and shops in the village or in a near-by city provide a market for the product. Exhibitions and lectures arouse public interest, aid in forming a demand for the Arts and Crafts products, and tend to elevate the public taste in house furnishing.

In America the English example has been followed.

The Centennial Exhibition in Philadelphia, in 1876, aroused the American artistic world to the utter lack

FIG. 44. — A. SWEDISH HAND-WOVEN LINEN
B. HAND-WOVEN LINEN FROM AN ENGLISH VILLAGE WORKSHOP

of crafts work produced in this country. By 1893, at the Columbian Exposition in Chicago, it was possible to gather a fair collection illustrative of industrial art, and

the situation seemed more encouraging. These and the later expositions at Buffalo and St. Louis aided in creating a sentiment for beauty in all lines of decorative and applied arts as well as in the fine arts. In 1897, inspired by William Morris and his English followers, the Boston Society of Arts and Crafts was organized. The first organization of its kind formed in this country, its purpose was and is "to develop and encourage higher artistic standards in the handicrafts." The membership of the Boston society embraces not only those practicing some branch of decorative art, "Craftsmen" or "Masters," but also "Associates," those interested in the work, but not necessarily designers or crafts workers. A shop is maintained in which all articles for sale must have been approved by a jury. It is proving a financial success as well as a place that attracts those who desire beautiful objects not made by wholesale.

Other societies, following the same general scheme as that of Boston, have been founded in different cities, and shops more or less successful have been established all over the country. As might be expected, the standard of excellence is not always upheld. Amateurs, without a thorough training in design, have rushed into the work, and many of their products are not worthy of approval. Yet there is a distinctive quality about the articles found in such shops which attracts the thoughtful and artistic public.

These clubs, societies, and shops are but one branch of the movement. They provide a market for the handicraft worker, and, the best of them at least, assure the purchaser that he is getting honest wares. The criticism

is often made that the prices for these wares are too high, but he who buys may have the satisfaction of knowing not only that his purchase will be durable, but also that the man who made it is receiving something more than starvation wages.

Village industries have been started in this country, after the example set by the English. The crafts carried on are often revivals of old industries flourishing before the factory system crowded out all handwork. Old looms and old designs are brought out of attics, and under the guidance of trained hands, beautiful rugs, towels, coverlets, and many other articles are produced. Close to nature, with nature's inspiration, and under most favorable conditions, these crafts are carried on.

Deerfield, Massachusetts, is perhaps the most famous of the village industries. Here wood carving, metal work, pottery, weaving of many kinds, embroidery, and other crafts flourish, and the demand for the products always exceeds the supply. The sleepy New England village has been awakened to a new prosperity, worthy of its fine old homes and beautiful streets.

In mountain communities of Kentucky, Tennessee, the Carolinas and New Hampshire, old crafts which had almost disappeared have been nourished and given new life, and delightful products of the loom, also pottery and baskets, find their way into our homes through the Arts and Crafts shops. This development of the mountain industries has meant a broadening of the lives of the mountain people, has brought them in contact with the outside world, of which they know but little, and has added to their meager incomes. At Berea College

in Kentucky, which is a center for the mountain industries, a carefully woven blue and white "kiver" or coverlet often pays part of the school bill of a mountain boy or girl.

Rag rugs, hooked or woven, bedspreads, wonderful linens and cottons from these remote districts have added interesting possibilities to house furnishings.

Not only in the remote parts of our country may these old industries be found dormant, but in the heart of the most crowded parts of our cities as well. Many of the foreigners who come to us have great skill in handcrafts, but have no opportunity to make use of this skill. They must earn a living, and they have not the opportunity to earn it through this sort of work. At some of the social centers in the large cities opportunity has been given for men or women to work at those crafts in which they are skilled. Hull House in Chicago, for example, has looms and wheels on which these foreigners may spin and weave, and the exhibitions held show the products to be well worth encouragement. Lace making and embroidery by foreign girls have been developed in some cases, and the skill and artistic ability discovered are sometimes remarkable.

A different sort of community work has been developed by the Roycrofters in East Aurora, New York. Though more fully developed here, the idea is the same. A band of workers is collected under pleasant living conditions, working coöperatively. Each individual is given opportunity for the best expression of his ideas in the production of beautiful objects. The Roycrofters are best known for their bookbinding, which was the first

undertaking; but later cabinet work, clay modeling, terra cotta work, and ornamental black printing have been developed.

The Stickley United Crafts in Syracuse, New York, do cabinet making, furniture, leather, metal, glass work and textiles, and also publish *The Craftsman* magazine. The "Craftsman houses" mission furniture and hangings, metal work and ornaments adapted to these houses, have been their chief work.

A number of potteries have sprung up in recent years, with simplicity, beauty in color and texture, and appropriateness of decoration, true Arts and Crafts principles, as their guiding rules. The Rookwood Pottery, which was the first, has grown into a large business enterprise, still true, however, to its original ideals and increasing the beauty of its products yearly. Grueby, Teco, Dedham, and other potteries are outgrowths of the same movement. Newcomb College in New Orleans has combined the school and the workshop in its art department, and produces beautiful needlework, textile fabrics, pottery, etc., in sufficient quantity to put upon the market. These different enterprises carry out the idea of Morris, that, when the individual worker takes pleasure in his work, beauty will result. They are attempts to reconstruct the workshop in such a way that the workman may really "live" and that the product may give pleasure to the worker as well as to the buyer.

To realize more fully the ideals of the Arts and Crafts we must go to the schools and see what change has taken place there. What is the meaning of manual arts which has taken such a hold in the last few years?

Why has art teaching changed from painting of still life and impossible landscapes, "gardening," one prominent educator called it, to wood carving, block printing, metal work, and designing? The doctrine of work as an educational factor is spreading. The child is to be trained to use his hand and his brain together, to take pleasure in his work, and to appreciate the fact that beauty may exist in the simplest things, if only he has eyes to see it.

The Industrial Era of which Carlyle wrote is surely with us, and man has awakened to the fact that in industry is the hope of the future. He is also fast awakening to the necessity "to civilize out of its utter savagery the world of industry."

From the purely commercial standpoint the Arts and Crafts shops and communities have little strength. Compared with the great factory industries they are nothing, but the influence of their ideals is far spread. Possibly it is not as Ruskin and Morris hoped it would be, a means of solving the industrial problems of the age; but the same general movement which insists on better art in our homes is awakening the public to the need of civic beauty, and is perhaps caused by the same spirit which is arousing the industrial magnate to the need of more humane factories and factory surroundings.

The demand for greater beauty in every-day things has influenced not only the hand-made, but also the machine products. Furniture, rugs, textiles, ornaments of various kinds have felt the move toward simplicity. True, the result obtained by the machine product is often but a poor imitation of the hand-made, but often it is excellent in itself. Where absolute perfection of detail

is required the machine is marvelous, but where individuality is desired it is helpless. The machine-made must, however, fill the needs of the multitudes, but any addition of art to it must be encouraged.

Training in the school will develop a love of the beautiful in the child, and in time possibly we shall reach the state when a few good things will be more highly prized than many cheap things. The tendency of the age is toward buying the many things which show expenditure of money, but, as has been seen, there is a considerable force in society working against this tendency through a quiet appreciation of higher values.

Whether the result is shown in products of handicraft or in effort for greater civic beauty, the greatest accomplishment of the Pre-Raphaelite and Arts and Crafts movements, and the outgrowth from these, has been the sending of man to Nature. By opening men's eyes to the beauty of natural things they have been made to realize the hideousness of artificiality. Their lives have been enriched by the spirit of outdoors, and that spirit is leading to beauty in many lines.

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APPENDIX A

LABORATORY TESTS FOR TEXTILE FIBERS

OF the many tests which may be used to distinguish one fiber from another, only enough will be given here to serve the purpose of those who wish to analyze, in a simple manner, the fabrics commonly found on the markets. No attempt is made to provide a laboratory guide for a course in textiles.

Two kinds of tests used for identifying fibers are the microscopic and the chemical. Some tests are suitable for quantitative work, others only for qualitative identification. In some instances, notably in the case of linen and cotton in the bleached state, the chemical nature of the two fibers is so nearly identical that the quantitative tests are not very accurate.

In qualitative work, the high power microscope is the unfailing test and is the simplest one to apply. Combined with counting, it serves as a partial quantitative test when threads of different fibers are woven together, but not where two fibers are twisted together in one thread. The method of examination is very simple, as it is not necessary to prepare permanent slides. The untwisted end of a thread is placed on the slide dry, or better with a drop of water, and the cover glass put on. It is sometimes necessary to remove the sizing from a material by boiling, with the addition of a little sodium carbonate, and then washing, before a satisfactory microscopic

analysis may be made. For a thorough analysis one must be sure that each kind of thread in the material has been examined. The microscopic characteristics of the fibers have been given before and will not be repeated here.

Often a microscopic test may be made more satisfactory by staining the fibers or by treating them on the slide with a chemical which gives a characteristic test.

Staining with Iodine and Sulphuric Acid. Cotton and linen, when steeped in a solution of iodine in potassium iodide and then in sulphuric acid and glycerine, are stained blue. The cellulose, by the action of the sulphuric acid, is converted into amyloid, a starch-like substance which is stained by the iodine. The glycerine prevents the destruction of the fiber by the acid.

Three grams potassium iodide in 60 c.c. water, add 1 gram iodine, dilute before using with 10 parts water.

Three parts concentrated sulphuric acid, 1 part water, and 3 parts glycerol.

Fibers moistened first with the iodine solution, then with sulphuric acid solution.[1]

Methyl violet in alcoholic solution stains linen and cotton a deep blue and shows up the structure of the fiber very well.

Fuchsine in alcoholic solution stains linen and cotton pink. Unbleached linen retains the color. Bleached linen and cotton do not retain it when washed in ammonia.

Schweitzer's Reagent. When cotton is treated with an ammoniacal solution of copper oxide, the fiber swells and gradually dissolves. The action is slow and a characteristic structure is visible with the high power micro-

[1] Matthews. Textile Fibers, p. 338.

scope. Apparently the cotton cell has an outer and an inner cuticle, and in the swelling the outer one constricts the fiber, giving it the appearance shown in the figure. The inner cuticle is also shown. Linen swells in a somewhat different manner from cotton and dissolves rather more slowly. A faint blue coloration is visible in both linen and cotton. Silk swells and dissolves very rapidly

FIG. 45.—COTTON TREATED WITH SCHWEITZER'S REAGENT

in Schweitzer's reagent, as does artificial silk. Wool is apparently not affected at all.

Analysis of a Cotton and Wool Sample. (*a*) The sample is boiled for ten minutes in a 5 per cent solution of sodium or potassium hydroxide. The wool present is entirely dissolved, the cotton remains unaltered.

(*b*) The sample is steeped in concentrated Schweitzer's reagent.[1]

Two grams of copper sulphate dissolved in 100 c.c. of water. Precipitate copper oxide with a 10 per cent solution of sodium hydroxide. Wash the precipitate

[1] Proportions from Methods of Textile Chemistry, by Dannerth, p. 5.

thoroughly, dissolve in smallest amount of ammonia sulphuric acid for two or three minutes; the cotton is then washed out, the wool remains.

ERRATA

Page 226 (*b*) should read:

"The sample is steeped in concentrated sulphuric acid for two or three minutes; the cotton is then washed out, the wool remains."

The sentences "Schweitzer's reagent. Two grams of copper . . . dissolved in smallest amount of ammonia" should be a footnote.

Page 227:

"Analysis of a Silk and Cotton Sample." Insert "and" between "zinc chloride" and "zinc oxide" in the second line.

Page 228, second paragraph should read:

"Jute and hemp fibers contain ligno-cellulose, with iodine and sulphuric acid jute turns dark yellow."

[1] Loewe's Reagent. Ten grams of copper sulphate, dissolved in 100 c.c. of water. Five c.c. of glycerol added, then sodium hydroxide solution, until the precipitate is just dissolved.

scope. Apparently the cotton cell has an outer and an inner cuticle, and in the swelling the outer one constricts the fiber, giving it the appearance shown in the figure.

solution of sodium hydroxide. Wash the precipitate

[1] Proportions from Methods of Textile Chemistry, by Dannerth, p. 5.

thoroughly, dissolve in smallest amount of ammonia sulphuric acid for two or three minutes; the cotton is then washed out, the wool remains.

These tests may be made quantitative by drying the sample at 100° C. and weighing before treating, and by neutralizing the alkali with acid or the acid with ammonia after treatment, washing, drying, and weighing the residue.

Analysis of a Silk and Wool Sample. The sample is steeped for two minutes in a concentrated solution of hydrochloric acid. The silk is immediately dissolved, while the wool is hardly affected. If the sample is dried and weighed before and after treatment, the test will be quantitative. Loewe's reagent, given below, also serves to distinguish wool and silk. The silk is dissolved.

Analysis of a Silk and Cotton Sample. The sample is treated with a basic solution of zinc chloride, zinc oxide —very concentrated. The silk is almost immediately dissolved; the cotton dissolves more slowly, first becoming gelatinized.

The sample is treated with Loewe's reagent, an alkaline copper-glycerol solution. Silk dissolves readily, cotton is not affected.

Artificial and Natural Silk. Artificial silk is unaffected by Loewe's[1] reagent, even when boiled.

Artificial silk stains blue with iodine and sulphuric acid, dissolves readily in Schweitzer's reagent, and gives other tests similar to cotton.

[1] Loewe's Reagent. Ten grams of copper sulphate, dissolved in 100 c.c. of water. Five c.c. of glycerol added, then sodium hydroxide solution, until the precipitate is just dissolved.

Analysis of a Cotton and Linen Sample. The sample is steeped for two minutes in concentrated sulphuric acid. The cotton is converted into a jelly-like mass which may be washed out, the linen just begins to dissolve. The linen may be washed, then steeped in dilute ammonia and weighed to give a rough quantitative test. When the linen is bleached it dissolves quite readily in sulphuric acid, so that the reaction must be stopped at the right moment.

Jute and hemp fibers contain ligno-cellulose, with iodine, ~~and in~~ sulphuric acid jute turns dark yellow or brown and hemp becomes yellow or greenish in color. Combined with the microscopic tests, the staining tests are more reliable.

For further tests see

Dannerth. Methods of Textile Chemistry.

Matthews. Textile Fibres.

Matthews. Laboratory Manual of Dyeing and Textile Chemistry.

APPENDIX B

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[1] Certain of these books are out of print, but since they may be obtained in public or college libraries they have been included in this list.

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